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The Journal of HEREDITY

R. J. Camerarius

—His fifty-page "Letter" (1694) reported the first authentic experiments establishing the existence of sex in plants.

VOLUME 21 JUNE, 1930 NUMBER 6

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The

Journal of Heredity

Vol. XXI JUNE, 1930 No. 6

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COMING

Human Heredity

Twinning among Relatives—How Immigrants "Eat Out" the Native-Born—Decay of Ancient Civilizations—Hereditary Tumors.

Genetics of Cotton

A summary of knowledge of heredity of this important crop plant.

The Siamese Cat

A study of effect of environment in modifying coat-color.

The "Frizzle" Fowl

Expression and inheritance of an ancient and widespread feather abnormality in fowls.

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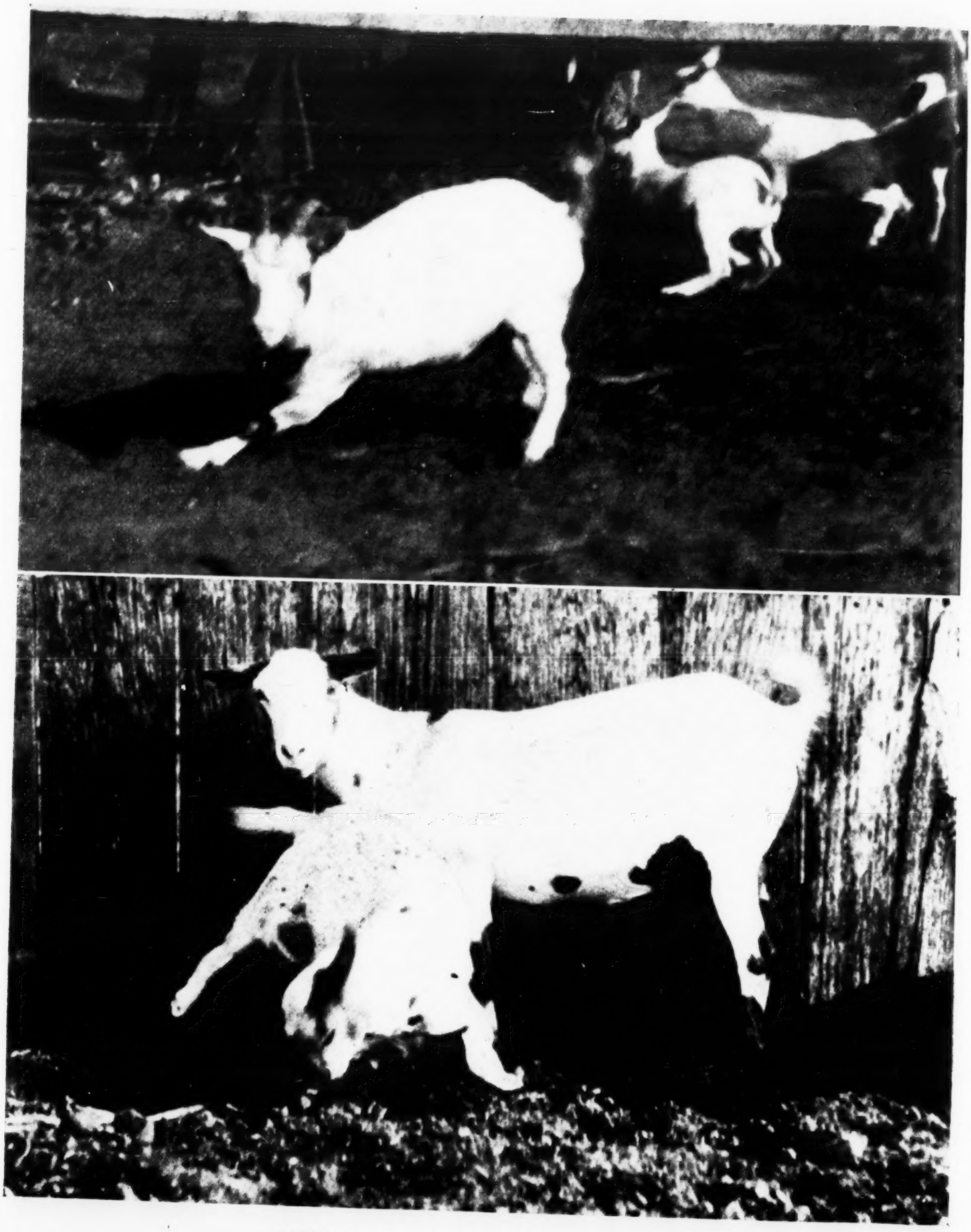


"NERVOUS" GOATS "IN ACTION"

Frontispiece

This strain of "nervous" goats has the peculiarity of losing consciousness when suddenly frightened. These two photographs show individuals in a Texas herd, in the act of falling to the ground as a result a such a stimulus. In the lower picture the kid is affected while its mother is not, as all members of the herd are rarely affected simultaneously.

"NERVOUS" GOATS

JAY L. LUSH*

A FLOCK of goats showing a peculiar hereditary nervous behavior was seen by the writer on several visits to a farm in Dickens county, Texas. Opportunity to determine by breeding tests the manner of inheritance of this peculiarity did not occur. However, the facts which were observed will be of interest to students of heredity in animals and perhaps also to those interested in the entire field of abnormal mental behavior.

This is probably the same peculiarity briefly noted by Hooper[4] as reported to him from certain regions in eastern Tennessee or Kentucky and as described in more detail by Dexler[3] who obtained much of his information from an article by White and Plaskett[7] and from a report made to Dexler personally by Dr. J. F. Gudernatsch of Cornell University. The cases reported by Dexler were from Maury county and from Marshall county, Tennessee, and agree in every essential respect with those seen by the writer in Texas.

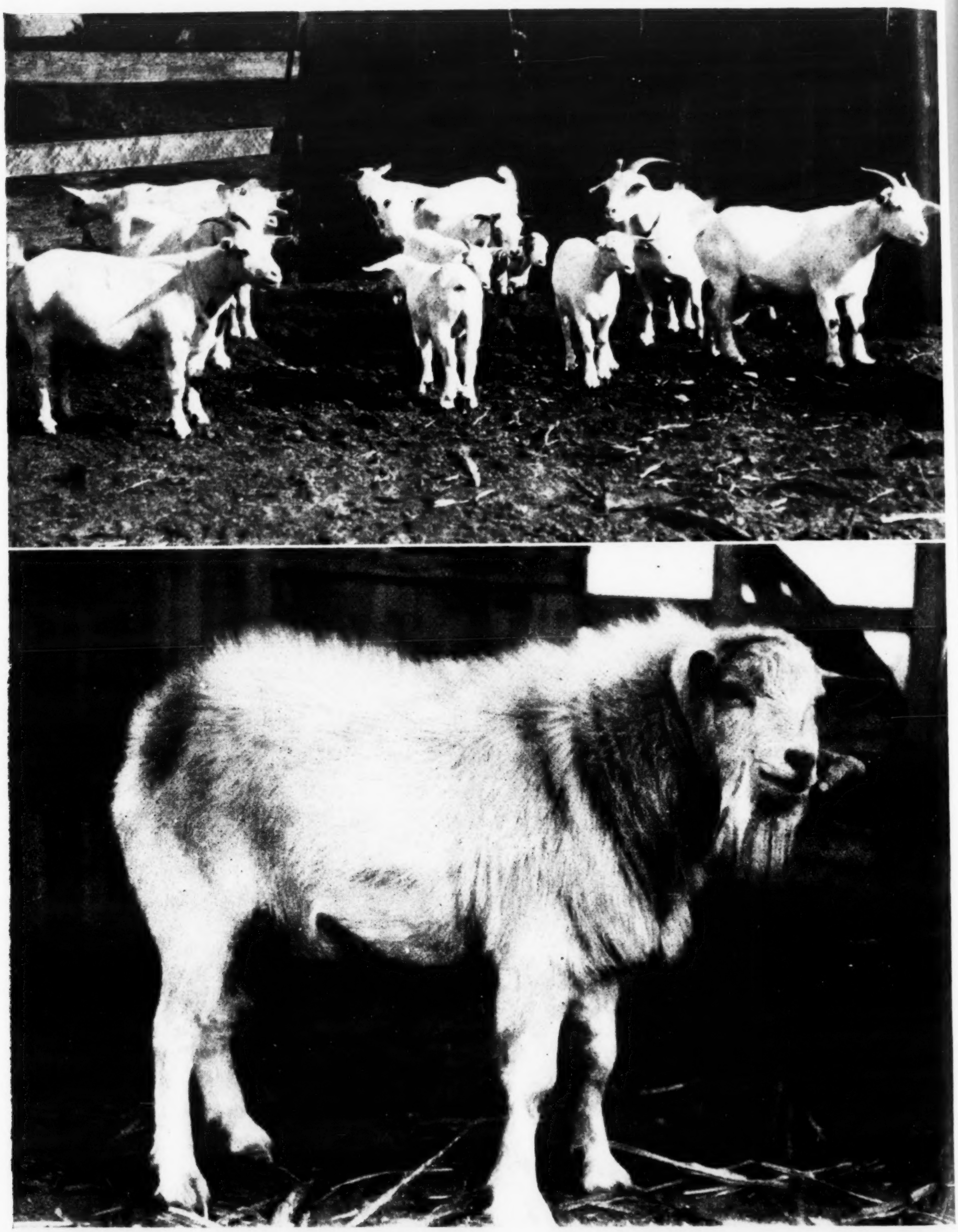
White and Plaskett reported that these goats were found in at least five counties in south central Tennessee (Marshall, Giles, Lawrence, Maury and Coffee) although they believed that the total number in those counties was not large. Their description of the behavior of these goats when frightened corresponds exactly with that observed in Texas but the observations of White and Plaskett were much more detailed and prolonged than ours were.

The Texas flock was brought directly from Giles county in central Tennessee. Dexler mentions a buck goat of this kind brought from Canada to Marshall county, Tennessee. The Texas A. & M. College also owned in its small zoo at College Station during about 1926 and 1927, one of these "nervous" goats of uncertain antecedents. No other cases of this kind have come to the writer's attention and, with the possible exception of the two individuals last mentioned, all seem to have come from a region in central Tennessee. Dr. White (in a recent letter to the writer) states that he observed a flock of goats like these in the summer of 1929 in Egypt between the Suez canal and the Palestine border. He also states that he shipped some of the Tennessee goats years ago to Professor Nagel, Nervous Disease Institute, Freiburg, Germany, and that Professor Nagel made quite a study of them.

Behavior of "Nervous" Goats

If these goats are suddenly surprised or frightened they become perfectly rigid. While in this condition they can be pushed or turned over as if they were carved out of a single piece of wood. This spell or "fit" usually lasts only a short time—about ten to twenty seconds. They recover the use of their muscles in the front end of the body first. Often one will see these goats, on recovering from fright, regain control of their forelegs enough to start running away, but the two hind legs will drag or move very stiffly as if the goat were still quite stiff from the loin back although fully in control of the muscles of its front legs, head, and neck. After having been thus frightened a goat cannot usually be frightened again, no matter how great the excitement may be, until it has had at least twenty or thirty minutes to rest. It is as if some substance were used up in a sort of nervous explosion and no further explosion could result until time enough had elapsed for a new supply of this substance to be formed.

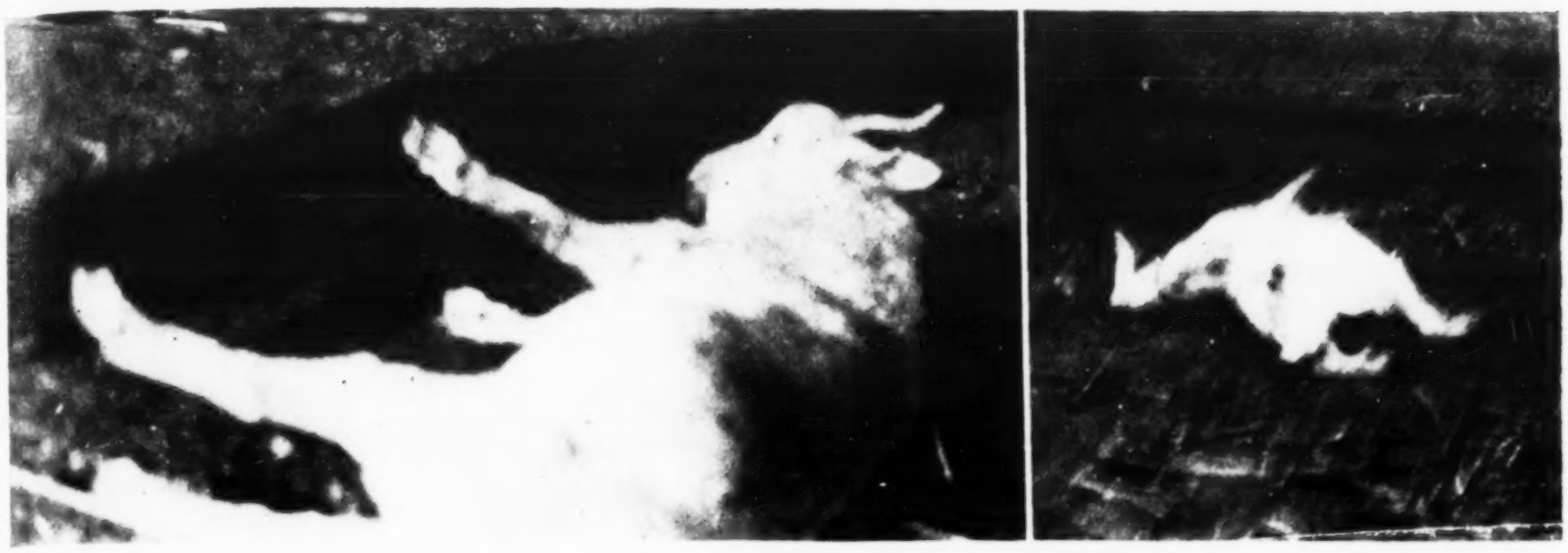
*Formerly of the Texas Agricultural Experiment Station, now of the Iowa State College.



"NERVOUS" GOATS "AT REST"

Figure 1

Two views of members of the Lovell herd of "nervous" goats at Dickens, Texas. Except for this peculiarity the goats are normal. The trait is of economic importance because such goats do not climb and jump as readily as ordinary goats, even the thought of such a proceeding apparently bringing on a transitory paralysis!



FALLEN AND STIFF WITH FRIGHT

Figure 2

During the fright-induced paralytic fits the animals are as rigid as though carved from wood. The fit only lasts a short time, and the animal regains control of its front legs first, the hind legs dragging appreciably for a moment. No cases of death from fright have been authentically recorded in spite of abundant opportunities.

The worst frightened of the goats usually fall over to the ground (through starting to run and being caught off their balance when the "fit" strikes them ?) but some become rigid in a standing position and remain utterly motionless for many seconds. If pushed over while in this condition they fall down as rigidly and clumsily as if they were statues carved out of wood, but recover in a few seconds and start to walk off, dragging their hind legs slightly at first, but very quickly recovering complete control of their entire bodies.

Fright can be induced in several different ways. The principal element necessary seems to be surprise. A loud noise such as the report of a shotgun or the sound of a galvanized iron wash tub landing on the ground after being thrown a distance of some ten or twenty feet was one of the surest causes. Or if two or three men, who had crept up close without being observed, would suddenly rush toward the flock yelling and waving coats in the air a considerable number of the goats would be sure to fall to the ground and most of the rest would become rigid in the normal upright position for several seconds.

In the writer's experience the entire flock (numbering some twenty or more head) did not on any occasion all become rigid with fright at one time. However, those individuals which ran away freely on one occasion were even more likely than the others to fall into the "fit" if a second scaring of the flock could be arranged twenty or thirty minutes later. The percentage of the flock which would succumb on any one occasion seemed to depend most upon the length of time which had elapsed since the last previous surprise.

Occasionally a goat would have one of these "fits" when no general scaring of the flock was evident. Apparently it would suddenly see some object close to it or (in the case of young kids) would attempt to jump over a stick or small object in the path and would become rigid with fear mid-way in this adventure. Such spells were usually shorter and less intense than those which were produced by intentional noise and commotion. Sometimes a momentary stiffness and dragging of the hind legs would be almost the only outward sign of fright.

White and Plaskett report being told that on rare occasions these goats are

so badly frightened that they die; that is, are literally "scared to death," but did not see this themselves. Dexler obtained no confirmation of this and doubts that it ever occurs. No case of death from fright occurred in this Texas flock in spite of abundant opportunity. The first goats of the Texas flock were brought from Tennessee to Texas solely to uphold the veracity of the Texas farmer who had been telling neighbors about their existence in his boyhood home in Tennessee. Naturally their odd behavior was put to the test again and again. As a form of Sunday afternoon sport the scaring of these "nervous goats" may not have been quite equal to a circus for entertainment and diversion yet it had its attractions and was often practiced.

The man who brought these goats stated, that they were quite unable to jump over fences of ordinary height (a statement confirmed in all accounts) but would find holes through which to crawl under the fences as readily as a hog would. In a hilly region, with stone walls for fences, this peculiarity made these goats more desirable than ordinary goats which of course would delight to scramble on and over stone walls.

Origin of the Nervous Goats

About the origin of these Tennessee goats, the only account I have found is that by R. J. Goode, Gastonburg, Alabama, who states (in a letter to the writer) that the history is about as follows:

> About 1880 a stranger came into a community in Marshall County, Tennessee, carrying with him four goats and what he described as a sacred cow. He went to a Dr. Mayberry and asked that he be allowed to keep his goats and cow at Dr. Mayberry's place and he, in return for his meals and keep for the animals, did odd chores for Dr. Mayberry. He stayed at Dr. Mayberry's place several months and later married an old woman in an adjoining community. He stayed during one farming season and at the end of the year came back to Dr. Mayberry and sold him the four goats. He then left with his cow without telling anyone where he had secured the goats or the cow nor anything about his personal history.

The peculiar behavior of these goats is almost unquestionably hereditary. The family history of the case and the fact that it persisted even when the animals were transferred from central Tennessee to the climate and forage of western Texas seem to attest its hereditary basis. From our own observations we can infer nothing as to the manner of its inheritance. All the animals of this flock showed this behavior and they were not crossed on other goats at all. Dexler believed (in 1908) that it Mendelized "— und bei Kreuzungen unregelmassig durchschlagt, also vermutlich mendelt."

Other Instances of Inherited Nervous Instability

Symonds reported[6] a family history in man of paralysis induced by excitement. This paralysis is made possible by an inherited instability of the nervous system. Cole and Ibsen have reported[1] a Mendelian recessive condition in the guinea-pig which they call congenital palsy and which is remotely similar to the condition here described in goats. They refer to certain conditions in other animals which conditions are primarily nervous disorders with an hereditary basis but which are distinct in symptoms from the "congenital palsy." Those include the familiar cases of waltzing mice and tumbling pigeons, epileptic seizures in man, and less well-known cases such as waltzing rabbits and rats. Cole and Steele have reported[2] the case of the waltzing rabbit in greater detail. Lord and Gates reported[5] a hereditary nervous peculiarity in mice which they call "shaker" and which is distinct both in appearance and in inheritance from the familiar "waltzing" in mice. They find that "shaker" is inherited as a simple Mendelian recessive.

It is difficult to avoid speculation as to what may be the mechanism in the nervous structures of these goats which causes them to react to fright in so peculiar and definite a way. Such

speculation, although otherwise fruitless, may lead to a deeper appreciation of the tremendous complexity and intricate interrelations of the parts which together make up such an animal as the (more or less) humble goat.

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6. Symonds, C. P. 1929. A Case of Family Periodic Paralysis with Attacks of Excitement. *Proc. Roy. Soc. Med.* 23:97.

7. White, G. R. and Plaskett, Joseph, 1904. "Nervous," "Stiff-Legged," or "Fainting" Goats. *American Veterinary Review* 28:556-560.

Books Received

BOOKS are acknowledged in this column as received, and such acknowledgment must be regarded as sufficient return for the courtesy of the sender. As far as space permits, books that contain material of special interest to the readers of the JOURNAL *will be reviewed in later numbers.*

PERSONAL AND COMMUNITY HEALTH, *by* C. E. Turner, Professor of Biology and Public Health in the Massachusetts Institute of Technology. Pp. 443. 62 Illus. 3rd edition revised and enlarged. C. V. Mosby Co., St. Louis, 1930.

Chapters on the Hygiene of Reproduction (including heredity) and on Essential Facts of Immunity are of most interest to *Journal* readers.

SEVENTY BIRTH CONTROL CLINICS, *by* Caroline H. Robinson. Published under the auspices of the National Committee on Maternal Health. Pp. xx+352. Price $4.00. Williams and Wilkins Co., Baltimore. 1930.

A history of birth-control clinics here and abroad, and a discussion of the results of the birth-control movement to date. It is said to be "becoming eugenic"—rather a naive admission that much of the eloquence to date of the birth-controllers on the subject of eugenics has been rather heavily infected with (pardon the slang) huey.

THE COLOR OF LIFE IS RED, or the Way Up, *by* Edward L. Holman. Pp. 104. Price $1.50. Richard G. Badger, Boston, 1930.

One of those inspirational books, in which red-blooded, shaggy-chested, Christ-like men of mixed metaphor rush out and tear large gaping holes in the environment any Monday morning.

MAGAZINE ARTICLE WRITING, *by* Ernest Brennecke, Jr., and Donald L. Clark. Pp. XI and 388. 9 Figures. Price $3.00. Macmillan Co., New York. 1930.

POULTRY HUSBANDRY, *by* Morley A. Jull, Senior Poultry Husbandman, U. S. Department of Agriculture. Pp. 639. 33 Chapters. 229 Illustrations. Price $4.00. McGraw-Hill Book Co., Inc., New York. 1930.

IDEAL MARRIAGE ITS PHYSIOLOGY AND TECHNIQUE, *by* Th. H. Van De Velde, M. D., formerly Director of the Gynaecological Clinic at Haarlem. Translated by Stella Browne. Pp. 323. 4 Parts, 17 Chapters. 5 Color Plates. Price 25s. William Heinemann, Ltd., London. 1929.

HEREDITY, ENVIRONMENT AND HUMAN FATE

A Review of *The Biological Basis of Human Nature*

BIOLOGICAL books in times past were of little interest to the general reader. The accumulating knowledge of the growth, physiology and heredity of toads, fish, insects and guinea pigs was not brought into relationship with similar processes in man. The subject remained one for specialists with no direct bearing on human affairs or interests.

Within recent years all this has changed and biology is placed almost on a par with physics and astronomy in popular esteem. Haldane and Huxley are names as familiar as Eddington and Jeans. The study of living things has been found to yield results of wide general interest and of first order importance in the development of civilization.

One of the most recent biological contributions of popular interest is a book entitled "The Biological Basis of Human Nature.* The author is exceptionally well equipped to treat of such a comprehensive subject, being a zoologist thoroughly conversant with the taxonomy, anatomy and physiology of the lower organisms as well as being an active geneticist with mathematical ability. In addition Professor Jennings enjoys among his colleagues an enviable reputation for sanity of judgment, tempered by the mercy of a humanitarian viewpoint. He might well be styled the American Haldane though lacking the latter's propensity for fine spun speculation.

It follows that any book by him deserves the serious attention of the intelligent public and the present volume is no exception. Not all that Professor Jennings has to say will be endorsed enthusiastically by his confreres nor indeed by the well-informed lay reader, but complete acceptance is hardly to be expected for any man's ideas. The book contains 384 pages including the index and is subdivided into sixteen chapters with references to the technical literature at the end of each chapter. There is some repetition of material but probably no more than is necessary for clarity.

The Advance of Science

Chapter eight furnishes the reader with an excellent starting point for here the issue between Wiggam and Watson is joined. Furthermore in this chapter the reader is led behind the scenes of science and is permitted to see for himself how haphazardly it works. "The advance of science is not a steady relentless progress over a wide front, making irretrievably its own ground over which it passes; its methods and results impeccable, inerrant and infallible. Science is rather a human adventure, with all that this implies of ups and downs, of advancement and retreat, of success and failure. Science is mankind in the process of forming habits. Like other organisms, from the lowest up, mankind forms habits by the process of trial and error."

He might have added that science, like fashions, has its fads. At any rate after reading chapter eight, and gaining an insight into the worknigs of science, we are prepared to proceed with the discourse "On the relations of heredity and environment to the characteristics and fate of human beings . . . ."

*JENNINGS, H. S. The Biological Basis of Human Nature. Pp. 384, 51 illus. W. W. Norton & Co., New York. 1930.

Returning to the beginning, the first four chapters treat of the mechanics of inheritance and development. In these the reader is introduced to Mendelian symbolism enlightened by numerous helpful diagrammatic representations of cytological processes.

A studied effort has been made to make the basic details of Mendelian heredity a part of the reader's store of knowledge rather than to encourage him to take these matters for granted. The presentation has not been planned to appeal to the mentally lazy and indeed the author has scant respect for those who wish to gain their knowledge by fifteen minutes of reading a day. "Any one who declines the labor of becoming familiar with the fundamental features of the genetic system and its method of operation cuts himself off from the possibility of understanding the nature of man and the origin of his peculiarities." This is a fair warning, but should not lead any one to fear an abstruse treatise understandable only to specialists. To be dull, stupid, or lazy is to belong to the lowest cast of humans in Professor Jennings' estimation and references to these three attributes continually "crop up" throughout the book where less kindly authors are accustomed to use "vicious," "degenerate" and "imbecile."

Despite the care that has been taken to keep the reader from becoming confused and going astray there are misleading passages in the first four chapters and a warning is hereby sounded to "look alive." Thus on Page 44 we find that mating a female (Drosophila) having bar eyes with a normal male results in all of the children—both sons and daughters—being bar-eyed. This, of course, is not true unless the female is homozygous for this eye form as is brought out some pages later. There are not many such sand traps and the larger share of persevering readers should arrive at chapter five well-equipped to understand the reasoning in the succeeding pages.

Hereditary Overemphasized?

Chapters five, six and seven introduce the reader to Professor Jennings' main thesis, namely that heredity has been over-emphasized at the expense of environment as a determining factor in human development. In chapter seven Professor Jennings puts Procrustes to shame and makes bedfellows of Pearl and Watson, doubtless to the discomfiture of both. From here on one feels that in attempting to counteract one evil the author perpetrates another of equal weight. He fears the neo-eugenicists will prove so convincing that we will adopt a fatalistic attitude and as a result nothing will be done to correct our defective external environment. Fatalism is a serious fault no matter what the cause, but surely trusting everything to external correctives, leading the superior person to believe that it is of little or no consequence with whom he mates, to engender the succeeding generation, has some serious elements of fatalism.

In his endeavor to save us from the pitfall of ascribing too much to heredity he comes periiously close to pushing us into another. "Thus ". . . . . there is no reason to suppose that there are any human beings who are predestined to develop cancer, whatever the conditions." Strictly perhaps this is true if we could discover the environment which would prevent cancer but in the present state of our knowledge it is unfortunately true that many persons are born with an hereditary pattern which predestines them to cancer.

Jennings, of course, arrives at his comforting position from a knowledge that many genetic defects can be counteracted by appropriate alterations of the environment. For example, a certain defective abdomen in Drosophila appears only in a very moist atmosphere and lacking this condition the genetically defective flies are nor-

mal. Similarly "reduplicated legs" is an abnormality which disappears when the developing flies are kept at a high temperature. "These [and many more] cases illustrate the fact that an inherited defect need not be one that is inevitable, inescapable, as is sometimes imagined."

But as East* has said "No yet discovered treatment, however, can force an ordinary fruit-fly to develop supernumerary legs. It does not have the proper packet of genes. The potentiality, so far as we know, is characteristic of only one variety." "During premillennial times the course of development that an individual can take will be pretty narrowly delimited by its heritage, for the amplitude of variation permitted by environment will remain small."

In discussing the effect on mentality of genes *vs.* environment the cases of four sets of identical twins are considered. The members of these twins were reared apart under widely different environments from very early ages.† When subjected to mental tests the results as between pairs were somewhat discordant, for while one set indicated no effect of environment on certain qualities the others showed a measurable influence. This is taken as evidence "that effects produced in one case by genetic constitution may be produced in another by environment." The conclusion may be in accordance with the facts but the same result would be obtained if the system of mental tests were defective. Actually the tests of these four unique sets of twins are of more importance to the psychologists than to the geneticists, in that they point definitely to serious errors in the tests used as measurements of innate abilities.

Improving Humanity

The possibility of improving the lot of humanity by tampering with the environment in which we live presents a strong appeal to those who have been laboriously attempting to alter organisms permanently for the better by recombining their genes. To change the environment seems simple but unfortunately in one sense the external environment is much like the genetic one in that most changes are deleterious. The organism is adapted to the conditions in which it is found and any alteration either of the organism or its surroundings throws the machinery out of gear. We know no more about the effects of environment and what to do about them than we do about genetic patterns and their beneficial rearrangement. We build big cities to provide the comforts and advantages of group co-operation and the consequences are slums, organized crime, sterility and epidemics. We develop industries, apply mechanical power to production, organize whole groups into compact nations and discover over-production, unemployment, poverty and destructive wars.

Humanity can expect no more from altering the conditions under which it exists than from altering the genic pattern of its heredity. Improvement by either method will be too slow to show results in a few generations but genetic improvement is relatively permanent while environmental factors will require constant attention and modification. Most thinking persons will agree that all possibilities for human betterment should be studied, and worthwhile modifications adopted, but we should be doubly careful not to have improvement in one set of conditions counteract advances in another. Thus we gain very little by progress in medical science if the end result is to preserve and increase hopelessly defective germ plasm which must always remain a condition requiring attention.

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*East, E. M. Heredity and Human Affairs. Chas. Scribner & Sons, 1927. P. 128.

†Reported in this Journal by Muller (vol. 16: 432-448, 1925) and Newman (vol. 20: 48-64, 96-104, 153-166.

No one can deny that much "blah" has been published in the name of Eugenics, the most ardent supporters of this cause having taken the position that propaganda before knowledge is justified. These matters are considered in chapter ten where Irving Fisher and Albert Wiggam receive some gentlemanly reprimands.

Under the heading of "Biological Fallacies and Human Affairs" are paraded a group of straw men and their shadows that are neatly disposed of in approved style. This chapter of pet aversions, is the least satisfactory of the sixteen and deals very largely with matters that are of no consequence to rigorous thinkers.

In discussing the pertinent excuses for marriage and the family, Professor Jennings notes a yearning of modern parents to be free from the burdensome care of their offspring—to turn this vexing problem over to the State. If developed to the highest efficiency this solution of family difficulties would result in human societies approximating those of the social insects. The present tendency in the direction of parental irresponsibility for children is interpreted correctly as a desire for a wider and less hampered exercise of the mating impulse. A study of the animals that have fully carried out a system of public care for their progeny shows that this system has resulted in the essential desexualization of society; the almost complete extinction of the mating art. He rightly concludes that "If man must look to this result, possibly the enthusiasm for this system will abate."

Race Crosses and Race Superiority

The question of race superiority is considered as well as the result of race crossing. Here is adopted the very questionable hypothesis of disharmony of organs in race hybrids, the chief support for which is afforded by the data of Davenport and Steggerda on "Crossing in Jamaica," data which for this purpose have been practically discredited by Professor Castle.* It is also stated that after race crossing there is a selective elimination of the inefficient combinations, but in a previous chapter we were assured that a single disadvantageous character (feeblemindedness) can be eliminated from the stock only after 68 generations, and this only if every feebleminded individual is prevented from breeding. Under our system every effort would be put forth to preserve these inefficient combinations resulting from race crosses,—making an added burden on society.

Every one is "fed up" on the subject of racial superiority and the eminence of the tall blue-eyed Nordics but there is nothing to be gained by denying that some groups of peoples are innately more able than others. True enough, the most backward of peoples excel in some direction but it will be a long time before the world sinks to the level where the abilities of these undeveloped peoples will be of value to the race as a whole. We are now concerned with developing a people capable of making use of our present civilization.

In one sense it is possible to form a more accurate conclusion with respect to the hereditary qualities of races than of individuals. In dealing with large numbers of peoples existent over a great length of time it is logical to suppose they have advanced as far in their development as their hereditary attainments permit. Their present position, therefore, constitutes an efficient measure of their capabilities under the conditions in which they are found and nothing is to be gained by advocating that under other circumstances they might excel.

Enough has been given to indicate the scope and trend of this interesting

*Castle W. E. Race Mixture and Physical Disharmonies. *Science*, vol. LXXI, No. 1850, pp. 603-606, June 13, 1930.

if somewhat provocative work. The quality of the presentation is slightly marred by the use of the interrogative form in introducing ideas but there is much excellent writing, some sly humor and mild cynicism.

No member of the American Genetic Association can afford to be without this book, but at the risk of being accused of knocking together the heads of my betters it is urged that those who have not already done so procure a copy of "Heredity and Human Affairs" by E. M. East.* The two books make excellent companion pieces and present the views of two outstanding men interpreting essentially the same biological facts. Their perusal will provide the reader not only with biological knowledge but will furnish as well an excellent study in personalities.

J. H. KEMPTON

Loc. Cit.

Sex-Reversal in Man

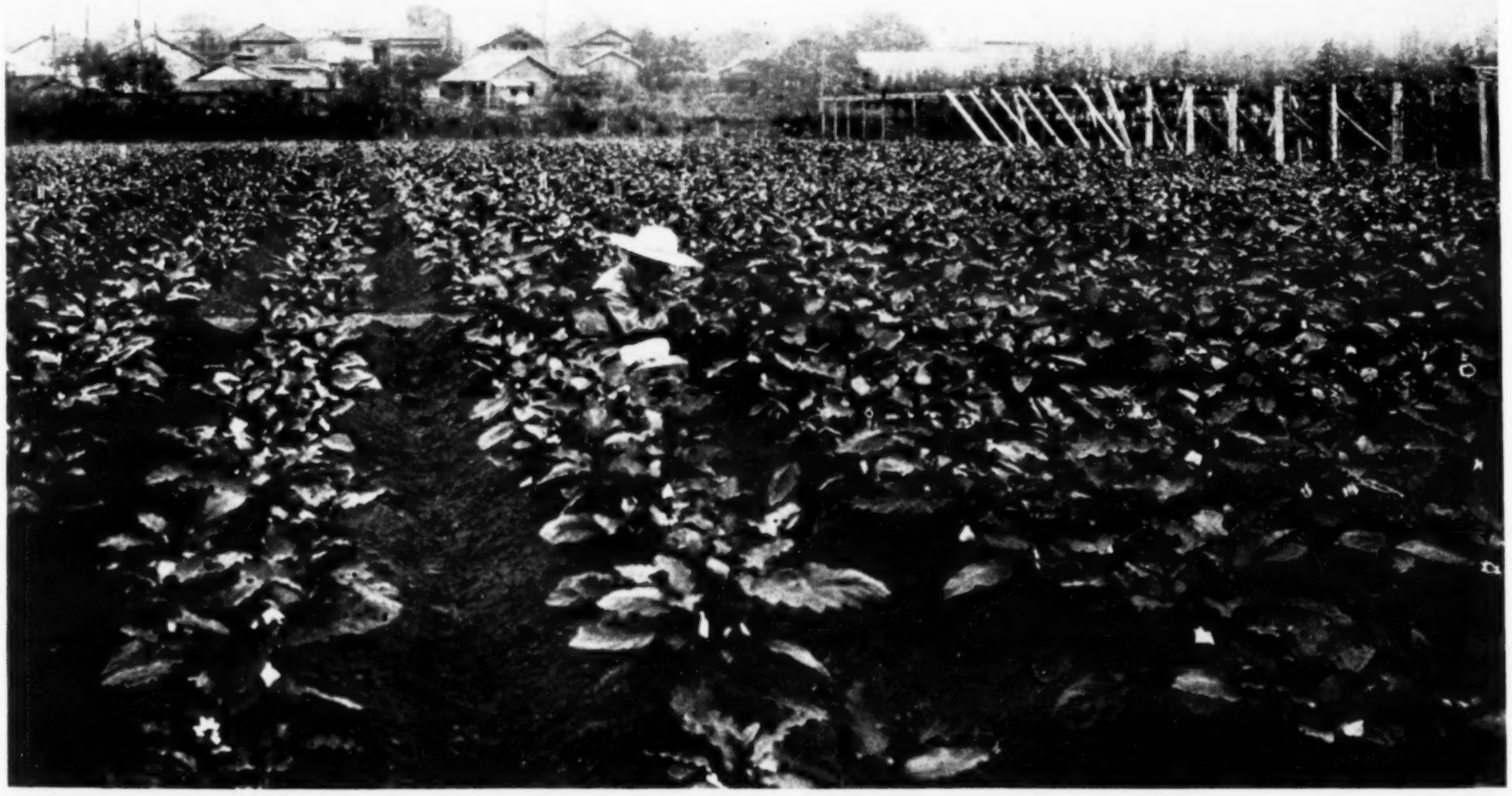
Dr. Erwin Strassmann, son of the well known gynecologist, reports in the *Deutsche medizinische Wochenschift* a remarkable case in which, in a woman, first masculine characters developed and then, after an operation, the feminine characters were restored. Such cases have been observed occasionally but they are rare. The patient had been married but a short time when masculine characteristics suddenly began to develop. A beard appeared, making it necessary for her to shave every three days. The fat deposits disappeared more and more, and her voice became masculine. A prominent Adam's apple developed. She became a pronounced baritone. On examination, a large tumor was discovered, which was removed by an operation. Thereupon the masculine character gradually disappeared. In a few months it was no longer necessary to shave more than once in three weeks. She got back her rotundity of form, and her face regained a feminine expression. The deep voice has remained; but it is evident that, for purely anatomic reasons, it is unlikely that the larynx, once the voice has changed, can again regress to the extent that the voice will again become feminine. On examination of the tumor, it was found to contain testis-like tissues. It may be assumed, therefore, that the genesis of the tumor was due to testis germ layers present in the embryo, which would explain the appearance of masculine characters.

"Berlin Letter." *Journal of the American Medical Asso.* March 22, 1930.

BREEDING "CROSSED EGGPLANTS" IN JAPAN

An Example of the Practical Utilization of Hybrid Vigor

YOITI KAKIZAKI
Saitama Agricultural Experiment Station, Urawa, Saitama, Japan

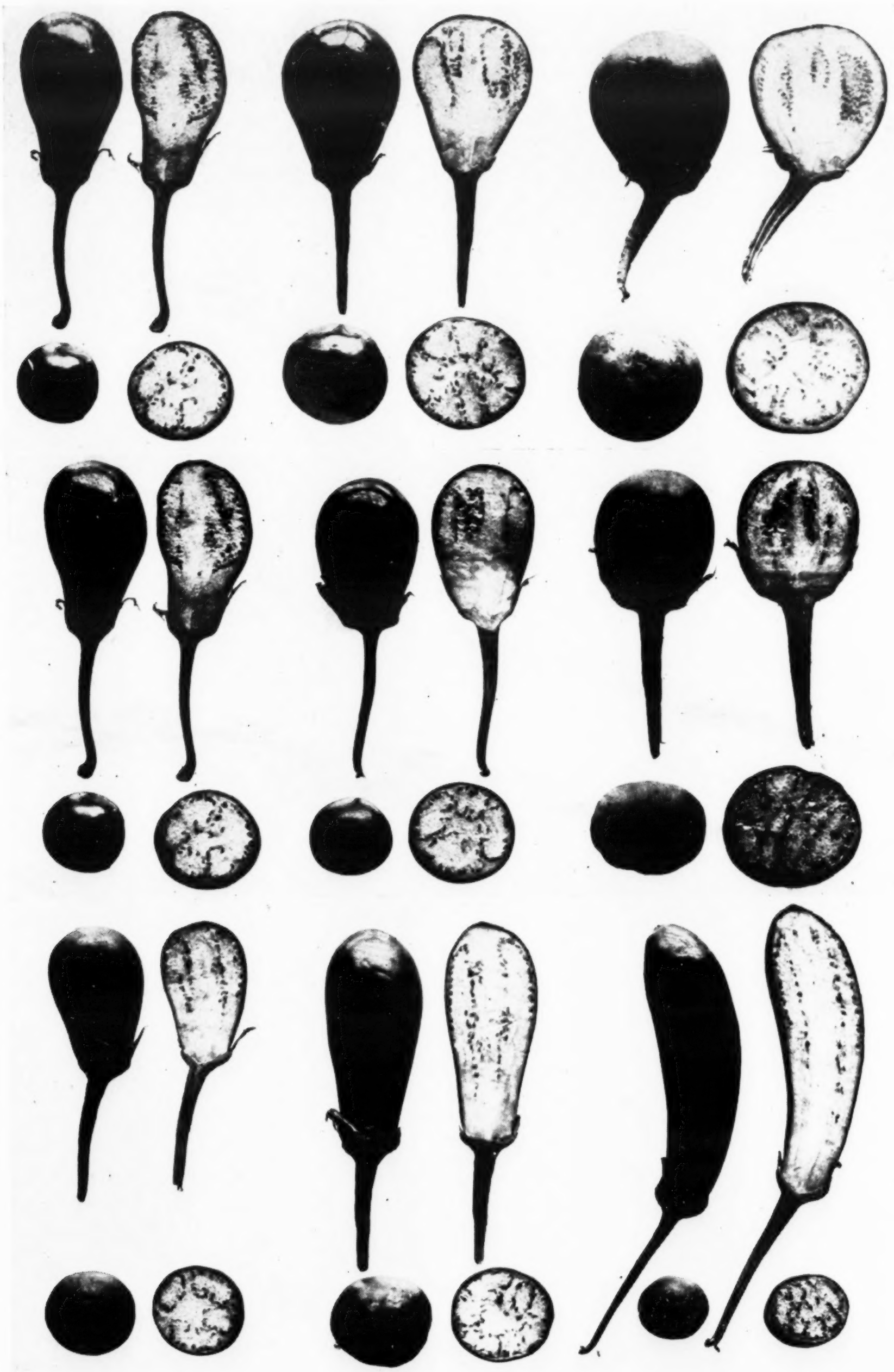


RAISING CROSSED EGGPLANT SEED

Figure 3

The Saitama Agricultural Experiment Station, Urawa, Saitama, Japan, is yearly furnishing gardeners in the prefecture with F_1 seed of two crosses of eggplants, one of which is illustrated by Figures 4 and 5, for the purpose of practical culture. The above is a part part of the seed field raising crossed seed at the station. To obtain the crossed seed the flowers have to be pollinated by hand. As many as 2,500 seed are obtained by a single pollination.

THE eggplant, *Solanum melongena*, L., is one of the most important vegetable crops in Japan, its fruit being used for various manners of cooking and pickling. Artificial pollination is readily performed, and a single fruit yields a sufficient abundance of seed so that a comparatively large culture can be produced by a minimum of effort. For this reason the discovery that certain crosses exhibited marked hybrid vigor has proved of considerable practical importance. As in other species, it was found that certain crosses are peculiarly valuable for practical purposes, and the ones that are now being used are the result of a series of experiments with forty-one intervarietal crosses and a comparison with their parental strains, during the four years 1922 to 1925. The present paper briefly summarizes the results and discusses our practical utilization of F_1 crosses of this plant.



CROSSES BETWEEN EGGPLANTS OF DIFFERENT SHAPES

Figure 4

Showing the fruit-type of the parents (the pairs at the right and the left) and the first generation hybrids in the center. The group at the top illustrates a cross that has proved of practical value in commercial plantings,—between the varieties *Sinkuro* (left) and *Sironasu*. The fruit of the hybrid is black, while that of the mother (Sironasu) is green; it is oval in

(Continued on next page)

A detailed discussion of the data and the correlations obtained is being presented in *Genetics*.

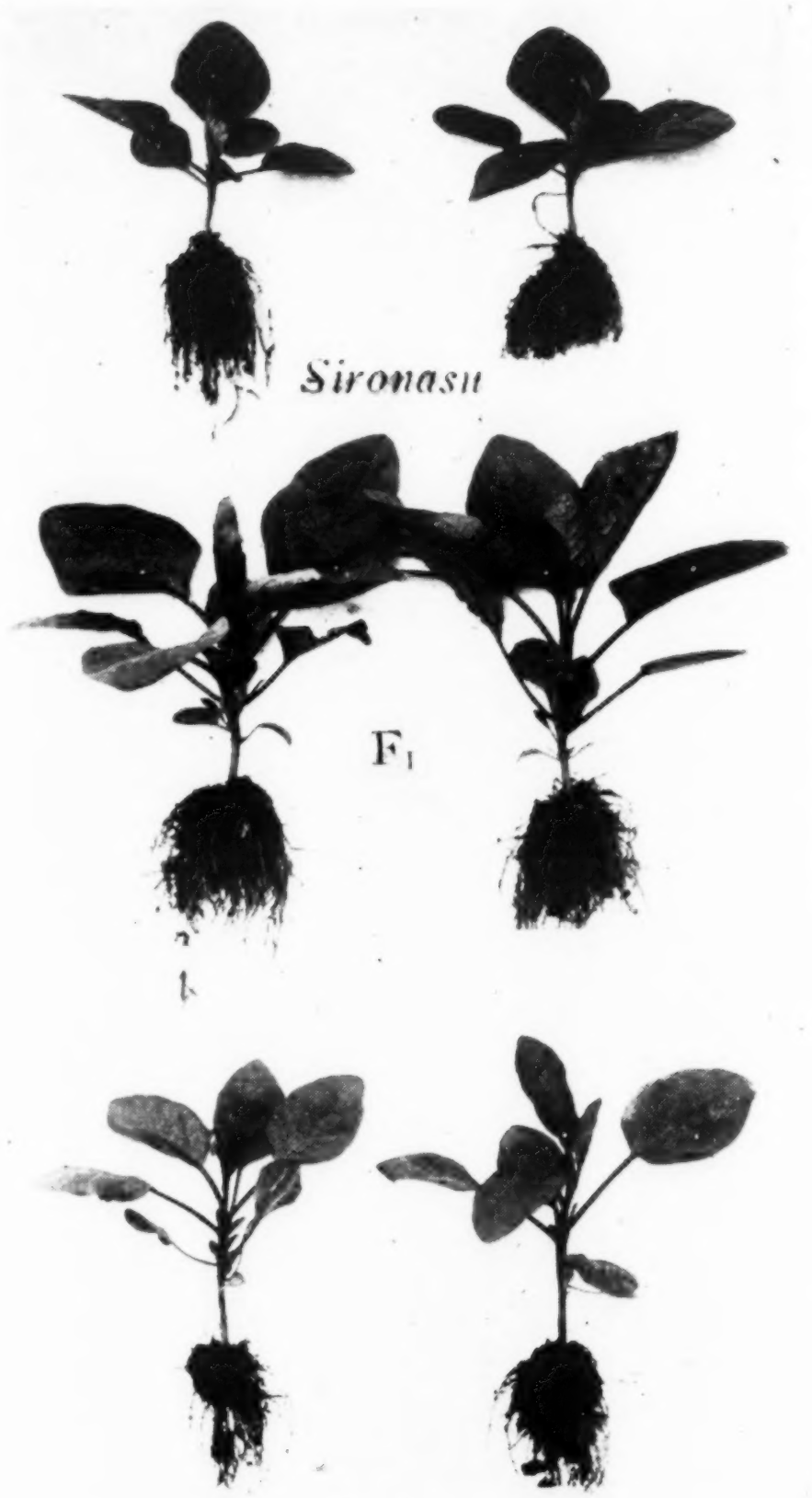
Material and General Methods

Artificial crosses were made among varieties which were assembled from various regions of Japan. For comparison selfed seed was raised from the two plants used for each cross, except with a few varieties, which had been selfed for three or four generations before using for crossing, and were judged as pure lines. It was essential that seeds of the parent plants be obtained by artificial self-fertilization, for, as the author has already reported,[2, 3] natural crossing sometimes occurs to an appreciable degree in the eggplant even though it is ordinarily self-fertilizing. The hybrid and the two parental strains were grown, as a matter of course, under as near as possible uniform conditions. Their seedlings were raised in a hot bed and replanted in the field in one meter rows fifty centimeters apart.

Weight of Seed

In the case of eggplants of the present experiment, the F_1 seed of most crossings gave immediate increase in weight over the selfed seed of the mother parent. In contrast to Sirks' conclusions[4] as to bean crosses, however, we were not able to find any combination in which the weight of the F_1 seed decreased in comparison with that of the selfed seed of the mother parent. Although there are a few crosses in which the F_1 seed somewhat decreased in weight, it is very apparent that the decrease was not due to the small weight of the seed of the pollen parent. On this point Wingard[5] obtained results just the opposite to those obtained by Sirks.

It is quite apparent that the increase in weight of the F_1 seed of the eggplant is due to the increased size of the embryo and is a manifestation of hybrid vigor. The variation in amount of increase in weight is regarded as due to differences of heterozygosity of the growth factors of the embryo, as well as to differences of the



HYBRID VIGOR OF SEEDLINGS
Figure 5

At top, Sironasu; below, Sinkuro; in the centre the F_1 cross between them. This cross is very vigorous and robust even in the seedling stage, and yields much more than either the parents or than the leading varieties; it is one of those which were selected to be used for practical culture.

shape and of thick flesh, characters that are ideal for the markets of Tokyo. The center group shows a cross between the oval variety *Sinkuro* and the round variety *Yuiki Yamanasu*, and below is illustrated a cross of oval and long types (*Turubosu Sennari* × *Kawabe Nagan-asu*). The fruit of the first generation hybrids is intermediate in shape between that of the parent types.

capability of the pericarp (which is not strictly a part of the seed but is of purely maternal origin) to furnish a suitable "environment" for growth.

Increase in Yield

Fruits of all the plants of crosses as well as of the parental strains were harvested at two or three day intervals throughout the yielding season. When compared with the lower-yielding parent, crosses yielded from 1.3 to 222.2 percent more, averaging 69.9 percent more, and all crosses exceeded in yield without exception. When compared with the average yield of both parents crosses range from −43.7 to +152.0 percent, averaging +36.1 percent. Only four crosses yielded less while the other 37 crosses yielded more. Further, as compared with the better parent, crosses range from −61.1 to +140.8 percent averaging +17 percent, and there are 12 less-yielding crosses contrasting with 29 that yielded more.

It is a well-known fact that the cross between varieties of diverse types tends to give a greater degree of hybrid vigor. This was the case with eggplants also. Most of the crosses which exhibited material increases in yield were bred by the parents which differed widely in characteristics from each other, although there were a few crosses not showing such a remarkable increase in yield in spite of the fact that they were produced by parents of diverse types.

This fact is in agreement with the assumption advocated by East and Jones[1] that hybrid vigor is the result of the bringing together of greatest number of favorable growth factors.

F_1 Expressions of Other Characters

Some other visible characters were observed besides those mentioned above. The result is briefly summarized as follows:

1. *The branching habit:*—In some varieties branches have a spreading habit of growth, being set almost horizontally, while in some varieties they grow up rather erectly. There are various types of branching habits forming almost a continuous series between these extremes. The F_1 cross exhibited more or less intermediate type between both parents but rather inclined towards the more erect one.

2. *The size of leaflet.*—The cross was about intermediate between the parents.

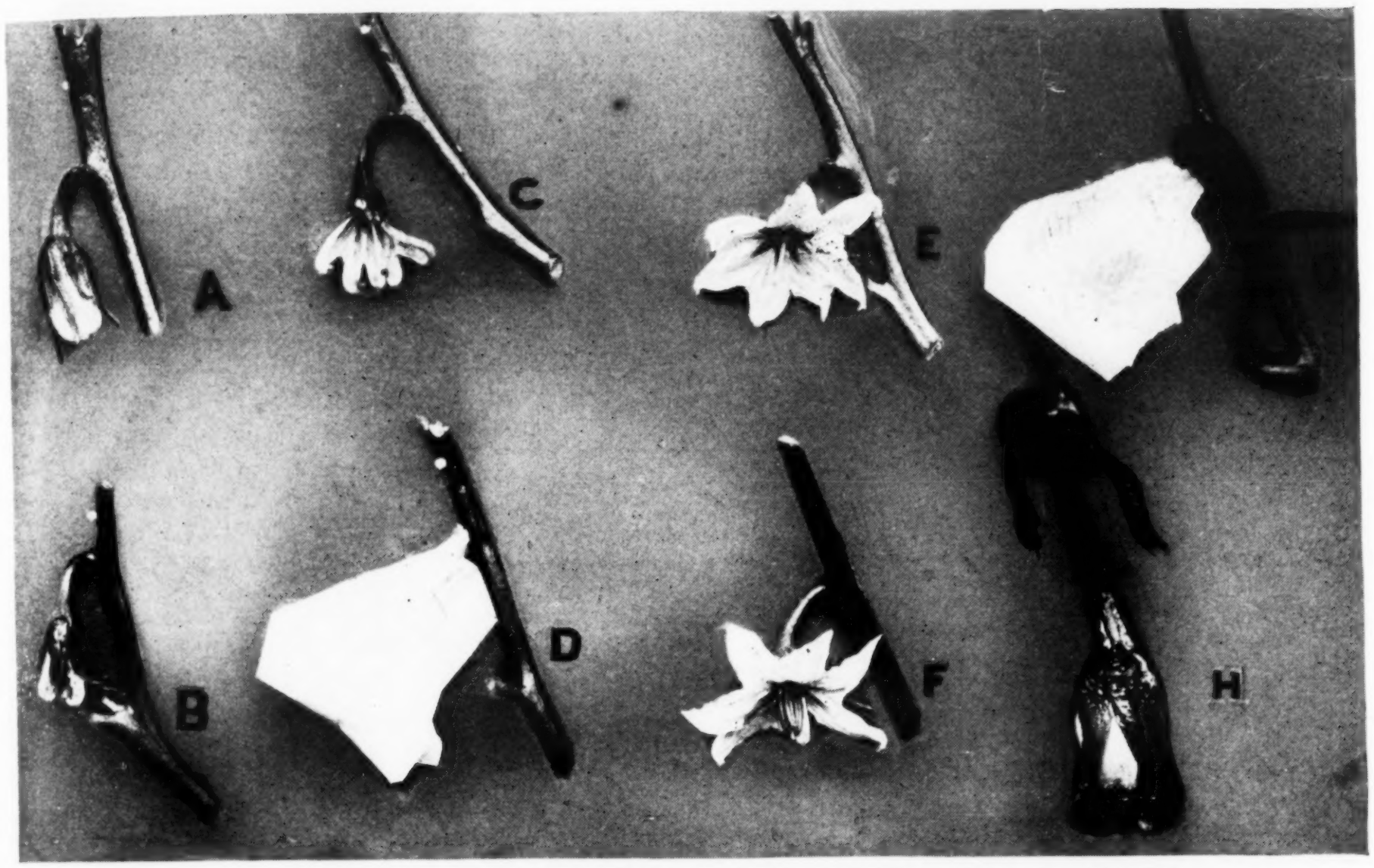
3. *The shape of fruit.*—In different varieties, the shape of the fruit varies from an almost round somewhat flat type to a very long one. In every case, the cross showed an intermediate type. Three examples are shown in Figure 5. Some varieties set ribbed fruits. In crossing between such a variety and a variety bearing plain fruits, the F_1 fruit was plain when the ribbing of one parent was slight, but had shallow ribbing when it was deep.

4. *The color of fruit.*—There are two main types, black and white. The former shows black or dark purple coloration on the skin of unripe fruits as well as on the vegetative part, while the latter exhibits no such coloration at all. It was already reported by the author[2] that these characters depend on a single factor difference, the black being dominant over the white.

5. *Spines on the calyx.*—Eggplant varieties have various amounts of spine on the calyx. The cross between two varieties bearing different amounts of spine inclined very nearly towards the less-spined type.

Crosses Being Used for Practical Purposes

For the practical use of the F_1 cross of eggplants, it should be of suitable shape and quality of fruit for marketing besides being superior in yielding ability and time of production. It is desirable also that the crossed seed be produced and raised with a minimum of effort. In the oval type one fruit gives 800 seeds or so in general and in the long type far less, while 2,000 or more seeds are obtained per fruit in the round type.



PROCEDURE OF CROSSING THE EGGPLANT FLOWER

Figure 6

A, flower in the bud stage suitable for emasculation; B, flower at the same stage showing the inner part; C, emasculated flower bud; D, the same wrapped in a piece of paraffined paper secured in position with a pin; E, emasculated flower fully open and with the stigma receptive; F, flower fully open with anthers in condition for pollination; G, pollinated flower wrapped again and marked by tieing a piece of woolen yarn; H, the young fruit five days after pollination.

From these points of view, two crosses, *Sironasu* × *Sinkuro* and *Kintyaku* × *Sinkuro*, among the crosses studied were selected as the most superior for commercial use. These two crosses are very vigorous and robust from the time of germination, and correspondingly their seedlings are grown quite easily (see Figures 4 and 5). The fruits are glossy black in color, oval, and of thick flesh, all these characters being suitable for markets in Tokyo—to which most of the vegetable crops in the prefecture of Saitama find their way. Moreover, the large number of seeds per fruit facilitates the practical use of these crosses, since both the mother varieties average as many as 2,500 seeds per fruit.

In regard to yielding abilities of these crosses, a trial was made for four years in comparison with *Sinkuro* which is the most popular variety in the prefecture. The two crosses increased by 75.7 and 50.8 percent, respectively, over *Sinkuro* in average yield of the four-years' test. The crosses have been proved superior also by trials conducted independently by ten gardeners in different regions of the prefecture: the average index-numbers of yield of the ten trials were 190 for *Sironasu*×*Sinkuro* and 167 for *Kintyaku* × *Sinkuro*, when 100 was for the yield of the universal variety in each region.

The Saitama Agricultural Experiment Station is now yearly furnishing gardeners in the prefecture with F_1 seed of these two crosses to be used for the commercial culture in an amount sufficient to plant about one hundred acres (see Figure 3). In addition to this, a certain amount of seed of the same crosses is raised by a few of the more progressive gardeners in the prefecture who have been furnished with seed stock of the parental

varieties, and the crossed seed is distributed yearly to other prefectures of the country by certain commercial seed dealers.

The Technique of Cross-Pollination

The author[2] reported the result of observations on the flowering habit and the flower structure of the egg-plant. The first flower appears on the seventh to thirteenth internode of the main stem. Branches arise from some of the nodes below the first flower, as a rule, the branches arising from the higher node being the more vigorous.

It is desirable that branches other than those from the upper one or two nodes be cut off, since lower ones will bear only poor seed-fruits. The first flower on the main stem is also better cut off, as not only it does not promise a rich seed-fruit but, if it grows to fruit, it is liable to make the growth of the plant considerably poorer. Thus, the second flower on the main stem and the first flowers on the branches left to grow are most suitable for crossing and should be used. If these flowers cannot be used owing to some reasons such as an insect injury, delay due to long-continued rains, etc., the next flowers on the same stem and branches may be employed. Flowers later than these are not likely to produce healthy seed.

One or two days before flowering, the flower bud is quite large and easily manupulated in emasculating (see Figure 6). With a small pair of forceps, the stamens surrounding the pistil are seized and pulled out. The emasculated flower is wrapped in a small piece of transparent paraffined--or parchment—paper, which allows the flower to be observed and facilitates pollination, and the piece of paper is secured in position with a pin. The use of a small bag instead of a paper piece is less favorable, because the flower bud is directed obliquely downwards and so that, when it rains, water is apt to stand in the bag. The flower bud for pollen is also wrapped in a piece of the same paper.

The stigma matures as soon as the flower opens, and is receptive for a period of two or three days in general. The anther dehisces at the terminal pore soon after the flower has opened, but, when the flower is wrapped in a piece of paper in the manner as described above, the larger part of the pollen is preserved in the anther and remains capable of functioning for a period of about three days.

When the emasculated flower is observed through the paper wrap to have opened, pollination is performed. Pollen is obtained satisfactorily by splitting one side of an anther with the tip of a small pair of forceps so that the pollen is raised on the tip. The amount of pollen obtained from one side of an anther is sufficient to pollinate a flower, so that an anther can be used for pollination of two flowers. The flower pollinated is wrapped again in a piece of parafined—or parchment—paper, and is marked as pollinated by such means as tieing loosely about the stem a piece of woolen yarn.

Flowers thus treated give 80 to 90 percent of successful crosses.

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X-RAY EXPERIMENTS WITH DROSOPHILA

A. S. SEREBROVSKY AND N. P. DUBININ*
Central Genetical Station, Moscow, U. S. S. R.

IN the fall of 1927 after H. J. Muller published his remarkable X-ray experiments with Drosophila, we began similar experiments at the Genetical Laboratory of the Zootechnical Institute in Moscow.† At the very beginning of our work it was decided to study Muller's method of X-raying and then to study the problems which had arisen from Muller's discovery, and also to use his method with other animals (e. g. rodents by M. A. Geptner).

Like other experimenters who have repeated Muller's experiments, we also obtained the same results; this paper is a report of the work.

Studies of Lethal Genes

At first we decided to make the experiments in order to obtain lethal mutations and for this purpose we used the method which, as we found later, was used by Muller: namely, only males of *Drosophila melanogaster* were X-rayed and these were crossed with the so called *Bar-C*$_1$ females. The daughters of this cross had the following chromosome constitution: chromosome obtained from the mother *BC*$_1$ (with no crossing over), and chromosome obtained from the father (X-rayed). Such females when crossed with any male give either 2 ♂ : 1 ♀ which shows that the X-rayed chromosome did not have a lethal mutation, or 2 ♂ : 0 ♀, which shows that in the X-rayed chromosome a lethal mutation had occurred. This method is unquestionably the best as it always gives a definite result which may be verified in further crosses, as one-half of the daughters of this cross are heterozygous for lethal factors.

Certain experiments were carried out in another way in order to obtain visible mutations: X-rayed males were crossed to "double-yellow" (*yy*) females. Muller's experiments and ours were conducted under the following conditions: 50 kilowatt, 5 milliampere; distance from anticathode 16-17 cm; the time of exposure 24 and 48 minutes as used by Muller. Other durations of exposure were also tried, namely 30, 60 and 120 minutes, leaving the rest of the conditions unchanged, and the following results set forth in Table I were obtained.

The observed increase in the percent of mutation may be formulated thus. If at one hour of exposure the number of the chromosomes which showed mutation is *C*, then after two hours' exposure one can expect the number of mutations to be twice as large, but the number of mutated chromosomes will be $2C—C^2$, since in C^2 cases the coincidence will occur; in one chromosome two mutations will be found and in the other chromosomes none.

With further increase in the time of exposure, simultaneous appearance of three and four mutations in a given chromosome may be possible, and then the equation will be complicated. In our experiments only in one or two cases were two simultaneous mutations in the chromosome observed, thus the equation $2C—C^2$ is satisfactory, and if 12% of mutations was observed after one hour of exposure

*Translated by G. A. LEBEDEFF

†Besides the authors, J. J. Agol, V. N. Slepkov, V. E. Altshuller, A. O. Gaissinovich, N. O. Shapiro and V. N. Sidorov participated in this work. The Commisariat of Education and the Communistic Academy assisted financially.

‡Dr. Schechtman, Director of Government Roentgenological Institute, was in charge of the X-ray experiment.

then 6% at ½ hour, and 23% at 2 hours of exposure may be expected.

In a part of our experiments the exposure was not made continuously, but for one hour every twenty-four hours. In several experiments duration of exposure was prolonged to 4 hours, also not continuously: at first for 2 hours, and then after 2 days again for 2 hours. In a few experiments, 40-50% of mutations were obtained. The X-rayed male in general gave very few progeny. It is clear that lengthening the time of exposure with interruption or without raises the percent of mutation.

The study of lethal mutations showed that among the progeny of certain males mutation occurred very rarely or not at all; while at the same time among the progeny of other males mutation occurred very frequently; as in 27 daughters of 1 male a mutation was found in 6, while in another male out of 24 daughters a mutation was found in only 1.

The question arises whether this difference in the frequency of mutation is due to chance, or do certain males react differently to X-rays as in the above mentioned cases where 6/27ths of the spermatozoids of the first male and 1/24th of the second had mutations. The investigation of this question is of great interest, since if certain males react differently to X-rays, this would indicate the presence of certain physiological factors influencing the mutation process in the spermatozoa.

For the explanation of this question the distribution of 59 mutations of different males was thoroughly studied. Fifty-three males were X-rayed and 486 of their daughters (or 486 X-rayed chromosomes) among which 59 had mutations were studied. As shown in Table II these 59 mutations were unevenly distributed among the males, but the distribution of daughters among the X-rayed fathers was also uneven: there was one daughter for certain males and 29 for one particular male.

In order to find the effect of chance in the distribution of these mutations, the following experiment was conducted: we took 486 marbles (corresponding with the number of daughters), of which 427 were black and 59 red (corresponding with the number of chromosomes). These marbles were then distributed at random among the 53 males, but in accordance with the number of daughters obtained from each male. Table III shows the distribution of red marbles almost coincided with the distribution of mutations. This experiment was repeated twice and in the second experiment the male with 24 daughters had only one red marble and the male with 27 daughters had 5; at the same time one mutation was found among the progeny of the first male and 6 among the progeny of the second.

This experiment shows that the unequal distribution of lethal mutations among the progeny of the males studied is explained by chance. If there are any physiological differences in this respect they are very slight.

Other Mutations

Besides the above described lethal mutations all other types of mutation were obtained as may be seen from the following description:

(a) Semi-lethals appeared several times. One case is being thoroughly studied (Altschuller) as it showed peculiar and little understood variability of lethal effect. In crosses with *yy* females, lines with different percentages of males were obtained; there were lines with 3%, 10% and 25% males which could not be explained by any modifiers or external causes. The most plausible explanation seems to be the assumption of a certain mutability of the gene.

A similar case was reported by Agalov who obtained the line of mosaics. Mosaic was found to be due to the X-rayed sex chromosome. When mosaic male is crossed with *yy* ♀'s, it is transmitted only to males and to all of them, the majority of which

perish. Mosaic is expressed in the distribution of normal and diminished bristles.

(b) Of the visible mutations in the majority of the cases we obtained those already known, although as will be seen later many new allelomorphs appeared. Thus scute, white, vermillion, furrowed, miniature, rudimentary, forked, fused, and bobbed were obtained; certain visible mutations were new. At the distance of 0.2 below (right of) white appeared "shd", a mutation distinguished by diminished eyes and bristles and the splitting of many bristles. Another mutation with smooth eyes as in glass (III), and another with spoon-like wings, and several other mutations of which the loci are not yet known, were observed.

Several very evident dominant mutations (recessive mutations were not studied) were observed in the autosomes; except for hairless all the observed mutations were new: in one mutation short stout bristles, in another definite cut along the front and back edge of the wing were found. Another mutation resembled vortex, and is evidently its allelomorph. It is not yet known whether these mutations are transgenations or are due to more complicated changes in the chromosomes.

(c). *Translocation.* The first observed mutation was an excellent case of translocation with deeply cut edges of the wings and designated as *Xasta.* It was found that the flies with this mutation survive only when heterozygous, and in addition they have a complete crossover reducer in the right half of both the second and third chromosomes. As it is impossible to separate the second and third chromosome, and as there is a great loss of eggs in this mutation, it may be concluded that there is translocation of a great part of the second chromosome in to the third or vice versa (Serebrovsky).

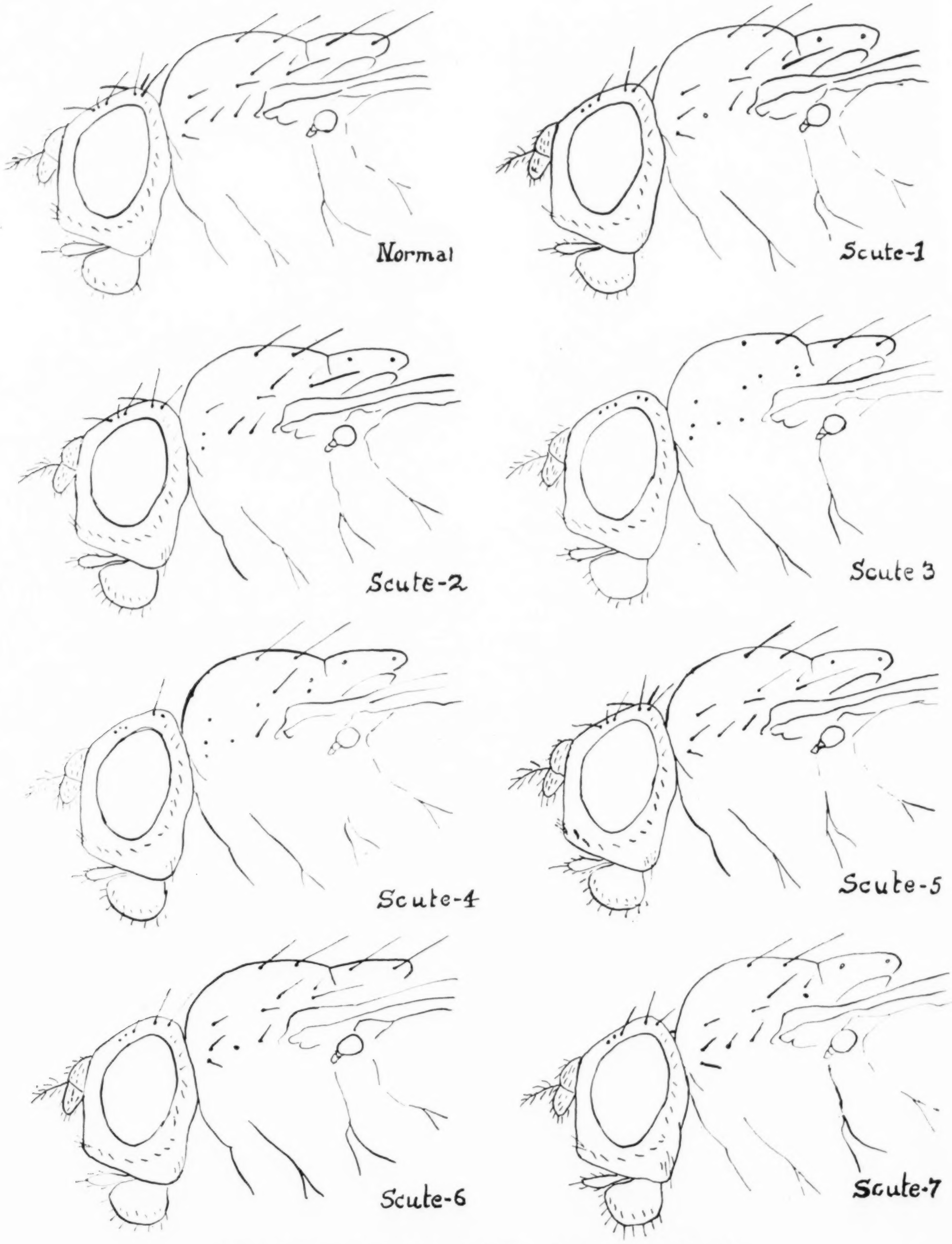
In the case of the translocation studied by Siderov there is a complete crossover reducer in the X chromosome below (right of) vermillion and at the same time there is translocation in the third chromosome. From the degree of change in the X chromosome it may be concluded that this translocation is quite large although there is no visible appearance.

Dubinin reports the third case of translocation when a part of the left end of the X chromosome was translocated to the right end, thus causing a visible mutation scute—2 (description further). It is interesting to note that if the translocation is removed by crossing over, then along with scute a semi-lethal mutation appears having the outward appearance of wrinkled wings. This is a good example of the presence-absence theory, as the appearance of the visible mutation was evidently accompanied by the breaking off of one part of the chromosome and the translocation to the other end. There is no possibility of explaining this case by "chemical changes."

(d) Inversion occurred in many cases and in certain experiments as often as lethal mutations. The fact noted by Muller that all types of mutations are increased equally by X-raying allows one to conclude that all mutations have the same mechanism. These conclusions are given in a special article (Serebrovsky, *American Naturalist*, 1930).

Allelomorphs of Scute

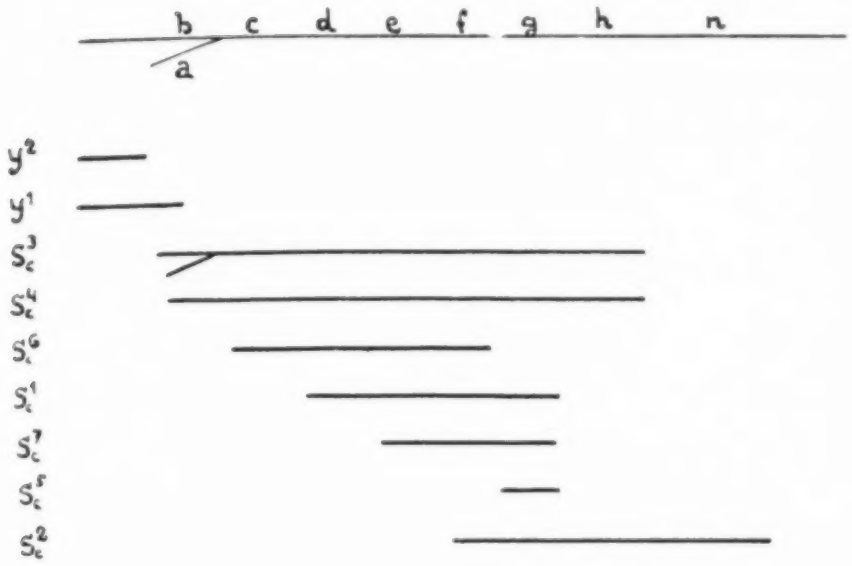
The most interesting results were obtained during the study of the scute mutation. Muller reported that in his experiment this gene did not appear, but on the contrary he obtained reverse mutation by X-raying the scute fly. In our experiments, to our surprise, this mutation was the most frequent with the exception of forked which appeared eight times. At the very beginning of our experiment Dubinin found two scutes (scute -2 and scute -3). In studying this gene our attention was called to certain appearances which coincided with our theoretic idea of the construction of



EFFECTS OF THE SCUTE ALLELOMORPHS

Figure 7

The various scute allelomorphs affect different bristle groups to different degrees. The differences are not due to modifyers, and are constant for the genes in question. Some of them have effects on other characters than the bristles.



"STAIRS OF ALLELOMORPHS"
Figure 8

This diagram shows graphically the explanation advanced for the phenomenon of multiple mutations. There is a portion of the chromosome which controls development of the bristle (*a-n*), and different groups of bristles each have their own centre. The number and location of the bristles affected by a gene mutation depend on the extent and location of the part affected. Thus Sc-3 and sc-4 are mutations affecting a large part of the bristle-controlling region, while sc-5 is a mutation of only a small part of the region and affects only a few bristles. (See Figure 7.)

the gene. Thus we decided to concentrate on the finding of new allelomorphs of scute. It should be noted that with Muller's discovery experiments could be conducted in such a way that it was possible to obtain several new allelomorphs of a certain gene.

Our problem of obtaining new allelomorphs of scute was readily solved and within a few months we found four new allelomorphs of scute: scute^4, scute^5, scute^6, and scute^7. In order to obtain these allelomorphs males X-rayed 1 hour, apricot (scute^{6,7}) or yellow (scute^{4,5}) were crossed with *yy* females. Thus through these crosses it was possible to study all the dominant autosomal and recessive sex linked mutations. Besides the four new scute allelomorphs: yellow (1), white (2), miniature (3), furrowed (2), rudimentary (2), forked (8), fused (1), and several good dominant autosomal mutations were found; several new mutations localized in the *X* chromosome were found but were not studied thoroughly. In Table V we added several new genes discovered in other experiments (during the study of lethals) to those listed above. These data confirm our findings that scute belongs to those mutations that appear regularly through X-raying. The study of our scute mutations led to the following conclusions which are given here briefly. These conclusions will be given in full by Dubinin in *Biologisches Centralblatt* and in special publications by Dubinin, Agal, Gajssinovitch, and Serebrovsky.

(1) All six of the new scute mutations were found to differ in their behavior from each other and from the old scute (scute 1); this difference does not depend upon different secondary modifiers. The replacement of all the other chromosomes, and the replacement by crossing over of all of the sex chromosome to the right of prune did not visibly effect the appearance of these allelomorphs which always retained their characteristic differences. Almost all of them affected the bristles, although scute-2 affected the wing construction also, and scute-3 had lethal effect on the female when homozygous. However the effects of the different allelomorphs on the bristles varied as is shown in Table IV. This is interesting in that it raises the question, are these repeated mutations or have we simply called repeated mutations those for which we could not find any differences (thus all whites seem to be repeated since their appearance shows no difference).

Scute is a gene which allows us to conduct thorough investigations of a given character, and to notice the smallest differences in appearance. Thus it will evidently be possible to determine whether repeated mutations occur. Theoretically such a repetition may be expected in a very simply constructed gene or in the sharp differentation of one gene from another.

(2) The conditions of the appearance of the six scutes enable us to suppose that at the basis of the three main types of mutation (transgena-

tion* translocation, and inversion) there is the same mechanism. Indeed the appearance of scute-2 was found to be connected with translocation of a piece of chromosome from the locus of scute to the very end of the chromosome, and the appearance of scute-5 was found to be connected with inversion of almost the whole of the *X* chromosome, while with the appearance of the other three mutations only transgenation occurred, or at least nothing but transgenation was observed.

(3) All the possible scute compounds were studied.

This investigation showed that in almost all cases the compounds led to a greater or lesser degree of reversion to the normal type (wild). The compound flies lacked only those bristles which were lacking in both the flies forming the compound. Thus sc^4 and sc^2 showed the reduction of bristles only on the scutellum and on the sternites as only those bristles are reduced in both scute-2 and scute-4. On the contrary the bristles on the head which are absent in scute-4 but present in scute-2 are present in the compound also, but changes in the wings present in scute-2 and absent in scute-4 are also absent in the compounds.

There is no reversion to the wild type except in such compounds in which neither of the component parts has any of the traits of the other. For instance scute-4 affects all the bristles that scute-6 does and also some others.

Thus the compound $\frac{\text{sc-4}}{\text{sc-6}}$ is almost similar to homozygous flies $\left(\frac{\text{sc-6}}{\text{sc-6}}\right)$.

The most pronounced is compound $\frac{\text{sc-5}}{\text{sc-6}}$ with a full reversion to the wild type; it may be differentiated from the normal flies only by very accurate biometrical studies. This is due to the fact that sc-5 affects only those bristles over which sc-6 has no effect and vice versa. Thus these two mutations are not allelomorphic to each other, but at the same time are allelomorphic to the other scutes.

We have given these phenomena the following explanation: In the chromosome there is a whole region affecting the bristles, and different groups of bristles each have their own centre. Transgenation takes from the given region one or another piece. Depending on the size of the piece taken out and the centre which is affected by transgenation, one or another type of external appearance is produced. Since the structure of the region of the chromosome is apparently very complex, it is very understandable why an exact repeated mutation never occurs.

The pieces of the chromosome affected by transgenation may be either short or long. Thus sc-5 is the shortest and sc-3 the longest. (See Table IV and Figure 8.) As the boundaries of transgenation may not coincide, then the allelomorphs may be arranged as "stairs of allelomorphs". At the same time there is the possibility of dividing the whole scute region into smaller parts, as a, b, c, in Table IV and diagram, and of finding the centre of what bristles are located in these regions. In the region g is found the centre for scutellars, but the centre for verticals-2 is "far" from it in region b; here also is found the centre for two bristles "behind the first pair of legs". It is interesting to note that these bristles are also affected by mutation yellow-1, while yellow-2 (Gajssinovitch 1929) has no effect on bristles which enables us to conclude that the centre for yellow pigmentation is to the left of the region *b*, and to the right of *b* is the region affecting the wings (*n*).

We thus come to the possibility of making a map of the gene or even of

*By this is meant the change of a gene in a chromosome, unchanged otherwise.

the whole region of the chromosome in which lie the centres for body pigmentation, bristles, and wings. This plan probably will be complex, and although most of the centre may be placed in linear order, two or three (*a*, *i*, and perhaps *f*) cannot be so placed. Our data are not sufficient, but as at the present there is a possibility of obtaining new mutations, the necessary new scute allelomorphs may be obtained. The greatest advantage of Muller's discovery is that now problems can be solved which previously required long and passive collections of chance material.

AUTHOR'S NOTE:—Our laboratory is studying the left end of the X chromosome and we shall be grateful to have any new mutations of *Drosophila melanogaster,* occurring in the region to the left of prune. Address: Moscow, Pjatnickaya 48, Timirjasevsky Inst.

TABLE I—Effect of Length of Exposure on Mutation Rate

Time of Exposure	*Number of Chrom. Studied*	*Number of Mutations*	*%*
30	139	14	10.1
60	354	43	12.1
120	37	12	32.4

Table II--The distribution of the males X-rayed for the number of daughters studied and for the number of lethals discovered.

The number of Daughters	The number of Mutations 0	1	2	3	4	5	6
1	4						
2	2						
3	3	2					
4	2	1					
5	3			1			
6		2					
7				2			
8	1	1	2				
9	1	2	1				
10		2					
11	1	1	1				
12	2	2					
13	3	1					
14		1	1	1			
15		1			1		
16			1	1			
24		1					
27							1
29						1	
Total = 53 males --	22	17	6	5	1	1	1

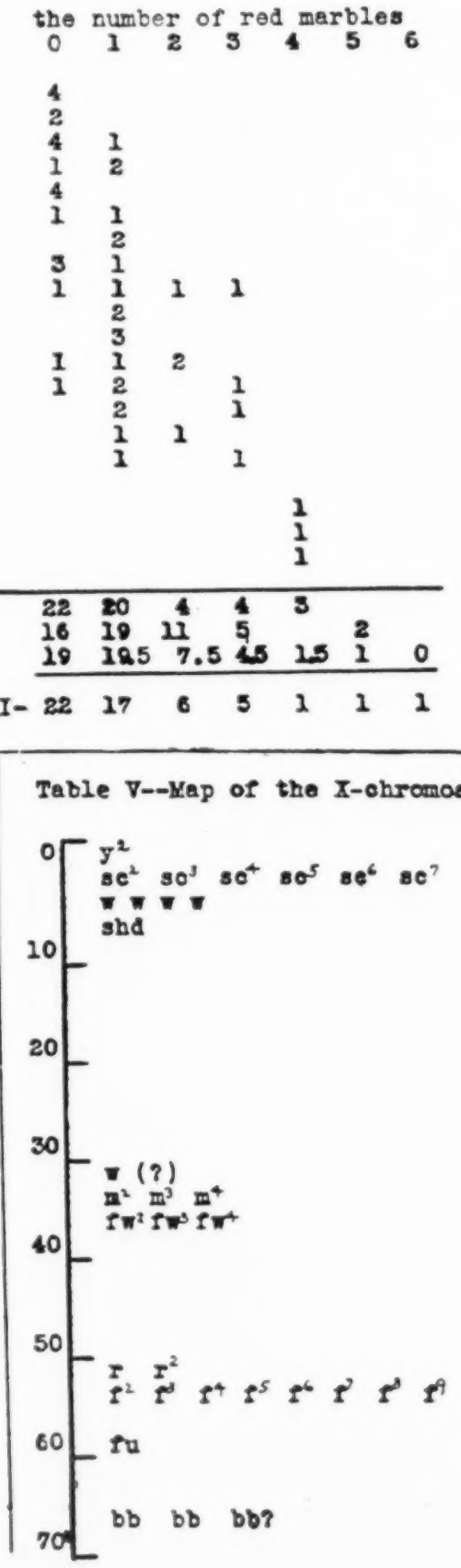
Table III--The distribution of the "males" for the whole number of marbles and for the number of red marbles.

The whole number of marbles	the number of red marbles 0	1	2	3	4	5	6
1	4						
2	2						
3	4	1					
4	1	2					
5	4						
6	1	1					
7		2					
8	3	1					
9	1	1	1	1			
10		2					
11		3					
12	1	1	2				
13	1	2		1			
14		2		1			
15		1	1				
16		1		1			
24					1		
27					1		
29					1		
Total	22	20	4	4	3		
Second Experiment	16	19	11	5		2	
Average	19	19.5	7.5	4.5	1.5	1	0
Totals from Table II-	22	17	6	5	1	1	1

Table IV--Bristle-groups reduced (-) in different scutes.

	dorsocentrals	supraalars	verticals 1-st	notopleurals 2-d	behind last pair of legs	verticals 2-d	presuturals	orbitals 3rd	notopleurals 1-th	ocellars	orbitals 1-st and 2-d	coxals	postverticals	abdominals	scutelars	humerals	postalars	
		a				b		c	d		e		f	g		h	i	
scute-1	+	+	+	+	+	+	+	+	+	-	-	-	-	-	-	+	+	Payne 1920
scute-2+	+	+	+	+	+	+	+	+	+	-	+	+	-	-	-	+	+	Dubinin 1928
scute-3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Dubinin 1928
scute-4	+	+	+	+	+	+	+	+	+	+	-	+	-	-	-	+	-	Agol 1928
scute-5	+	+	+	+	+	+	+	-	+	-	-	-	+	-	-	+	+	Gajssinovitch 1928
scute-6	+	+	+	+	+	+	+	-	-	-	-	-	-	+	+	+	±	Serebrovsky 1929
scute-7	+	+	+	+	+	+	+	+	+	-	-	-	-	-	-	+	-	Dubinin 1929

Table V--Map of the X-chromosome



HERITABLE CHARACTERS OF MAIZE

XXXV—Male Sterile

W. R. Singleton and D. F. Jones
Connecticut Agricultural Experiment Station, New Haven, Conn.

In 1923 several progenies of white flint corn from various sources were being selfed the second time. One of these progenies was found to be segregating for a factor causing the tassel to be sterile. This factor has been named "male sterile" with the factorial symbol ms_1. The plants are very similar to those described by Eyster[1] as male sterile, and it might seem that Eyster's male sterile should be designated as ms_1 since it was discovered first. Characters of this sort occur frequently, however, and when all are identified there will probably be several genetically distinct factors each causing the tassel to be sterile. Consequently, in maintaining the identity of the different factors it is quite important that the linkage relations with other factors be known. The male sterile described in this paper has been called ms_1 because it is so easily identified by its close linkage to the yellow-white endosperm locus, as will be discussed later. It has already been referred to as ms_1 by Beadle[2]. Sterile tassel seems a preferable name but the other has priority and will be used to avoid confusion.

Male sterile plants produce normal ears, and plants heterozygous for ms_1 are normal for pollen production as well. Sterile plants can be easily recognized at the time the normal plants are shedding pollen by the slender appearance of the tassel, the failure of the anthers to extrude, and by an examination of the anthers themselves which contain no pollen. See illustration.

We have not examined the reduction division of sterile plants but this has been done by Mr. George W. Beadle of Cornell University to whom we are grateful for the following information. The plants examined were grown from seed obtained from this station. He says, "The meiotic divisions are essentially normal. The spore cells round up, the spore wall develops but apparently the nucleus does not go through the first microspore division. At the time the anthers would normally shed pollen it is difficult to find even the remnants of the spores."

Some of the ms_1 plants were pollinated by yellow silkless (*Ysk*) and the F_1 plants were selfed the following year. In 1925 the F_2 plants were grown and classified for ms_1 and also for *sk*. Before planting, the yellow and white seeds had been separated and were planted in adjacent rows. Upon classification it was indeed surprising to find that all of the plants grown from white seeds were sterile while the plants produced by the yellow kernels were without exception fertile, a case of complete linkage. Later breeding results, however, have shown that there is some crossing over between *y* and ms_1. Backcrosses were used in studying this linkage in years subsequent to 1925. In the coupling phase there was a total of 295 parental combinations with 13 crossovers or 4.2 percent. Somewhat fewer data on the repulsion phase showed 112 parental combinations to 6 recombinations or 5.1 percent crossing over. Averaging the two we get 4.5 percent of recombinations. The 1925 F_2 data show no recombinations out of a total of 52 individuals. It is not surprising that none were found as they occur less frequently in an F_2 generation than in a backcross.

NORMAL AND STERILE TASSELS

Figure 9

Normal tassel (left) as contrasted with the more slender tassel of a male plant (ms_1). Anthers fail to extrude and contain no pollen.

In a cross with purple plant (*ABPl*) the F_2 generation showed that ms_1 is also linked with *Pl*, which was expected since *Y* and *Pl* are in the same linkage group. Only the purple, *ABPl*, and sun-red plants, *ABpl*, were used in calculating the linkage between ms_1 and *Pl* as the exact composition

of the green plants was uncertain. The following numbers and their ratios were obtained:

	Number	Proportion	Expected (9:3:3:1)
Purple fertile, *ABPl Ms*.....	73	.608	.5625
Purple sterile, *ABPl ms*.....	15	.125	.1875
Sun-red fertile, *ABpl Ms*....	14	.117	.1875
Sun-red sterile, *ABpl ms*.....	18	.150	.0625

Calculating the linkage value we get 28 per cent using either Emerson's[3] method or the one given by Babcock and Clausen[1]. Immer's[5] method shows a recombination percent of *Y-Pl* (average 28.5) that it is impossible to state on the basis of such a small population whether ms_1 lies between *Y* and *Pl* or whether it lies on the opposite side of *Y* from *Pl*. More data will be necessary to establish this point.

Considering only the one character, *Msms*, the F_2 population gave a total of 87 Ms_1 to 33 ms_1. This is reasonably close to the expected 3:1 ratio, indicating simple Mendelian inheritance of the ms_1 factor.

Value In Production of Crossed Seed

The factor ms_1 has some commercial possibilities in the production of crossed seed corn. The common method of producing such crossed seed is to grow the two parents in alternate rows, detassel one and let it receive all its pollen from the other. Detasseling a large field is not only costly but tedious and even when the greatest care is exercised some few plants of the seed parent send out tassels which shed pollen, and cause some contamination. It is a safe estimate that there is at least 5 percent of contamination from this source.

If the ms_1 factor is to be used, the seed parent must be maintained in a heterozygous condition both for *y* and for ms_1. Only white seeds should be planted in the crossing plot and it will not be necessary to detassel the plants produced as they will be male sterile with the exception of about 5 percent of recombinations. It is true they will cause some contamination but it is hoped this will be no more than normally occurs in the production of crossed seed by detasseling.

At the Connecticut Experiment Station ms_1 has been introduced into a stock of Burwell's Flint by crossing and repeated backcrossing to Burwell, so that the stock of Burwell containing ms_1 is identical in every other respect to the original one. It is planned to use the ms_1 Burwell stock in the crossing plot with Leaming to produce the commercial crossed seed of Canada-Leaming, a Flint-Dent hybrid recently produced and introduced by this station. Possibly a considerable saving in the cost of production of crossed seed can be effected by the use of the male sterile factor, ms_1.

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HEREDITY AND ENVIRONMENT IN CHILD DEVELOPMENT

HAROLD ELLIS JONES*
Director of Research, Institute of Child Welfare, University of California

IN Monroe's Cyclopedia of Education (1911), an article on Child Study presents the following statement: "At three years of age the infant has become a human personality, with considerable power of self-direction and with some individuality." In the light of modern investigations of the pre-school child, this statement now appears somewhat humorously out of date. The author's implication is that children have little individuality before three years, and that variability appears only after a period of growth. Any one who studies the records of, for example, nursery school children, cannot fail to notice wide differences in almost any trait that may be considered. This simple fact of observation has had profound effects upon contemporary theories of development. When, in recent years, we began to pay closer attention to the actual behavior of children, we noted that many of their traits . . . . their jealousies, their love attachments, their temperamental quirks and flaires, their interests in social play or in competitive modes of expression, could be traced back to the age of four, three, or even earlier. The dogma arose that since these distinctive traits of character are present during this period, *they must be the product of the kind of environment* to which the pre-school child has been subjected. Many students of children have accepted, almost as a truism, the statement of a prominent psychologist that "any individual is made or broken before the age of five years." By controlling the pre-school environment, it is often said that we may guide the whole course of development. This doctrine, with slight variations, is so commonly encountered that it is perhaps unnecessary to document it, but the following excerpts, from journals appearing within recent months, may be used as illustrations.

From *Childhood Education,* in an article by a well-known authority: "We all come in contact with children who are unpleasant to live with—whining, domineering children with tantrums, children who are very dependent. Such children are the product of home influences that have not been wise."

From *American Childhood,* in a report on the nervous child . . . "Neuroses, nervousness, and nervous breakdowns, are in reality the late stages of a disease which shows itself early in childhood. We can prevent this disease . . . . if we can recognize the symptoms early, and begin our preventive work at the first appearance of the dread signs."

From the *Journal of the American Association of University Women,* in a discussion of the principles of mental hygiene applied to young children, "Psychiatry has a great lesson to teach concerning the emotional life of the young child. Its practice has revealed devastating effects of mistakes made in the early lives of sufferers from mental disorders."

Even Professor Judd, who has offered significant criticisms on some of these matters, states in *School and Society,* "Impressions received in early childhood and translated into emotional reactions are of far-reaching importance in determining the individual's later habits. I am disposed to venture the statement that it is diffi-

cult to exaggerate the influence of these early experiences."

Training and Germ Plasm

If, however, we consider this problem from another point of view, we hear it asserted that a child's learning capacity increases as he grows older, increases at least up to the age of 18 years. Is it probable that while his capacity increases, what he actually learns decreases? We know that his environmental exposures become wider, that his social contacts are greatly extended, that his repertoire of interests and emotional likes and dislikes increases; shall we assert that while all these factors are increasing, the rate of change in character traits is on the wane? Quite possibly this is really the case, particularly in the field of emotional dispositions, and in any traits in which the early tendencies exert a blockage against re-education. Capacity and the use of capacity are not always well correlated. It sometimes happens, furthermore, that a person uses an increased capacity merely to strengthen the reaction patterns established at an earlier level, (as in adult rationalizations of early fears). In the present state of our knowledge, however, these relationships are much too involved to be expressed in any simple formula. It is true that until recently the pre-school child has been neglected and that we have here a most promising field for training, but it appears in the eyes of some writers that we are now over-reacting to our previous neglect, and placing more stress than is justified upon the rôle of the environment in early childhood. Instead of blaming the pre-school period for the major faults and virtues of character, we are told that we might equally well (so far as logic is concerned) go a step further and attach our emphasis to the determining or predisposing influence of the germ plasm; not only in the development of intelligence but also with respect to temperament and character. In a striking study in the Colorado schools, Professor Heilman has shown that of school children of the same age, the enormous variability in scholastic efficiency can be attributed to differences in educational exposure to an extent not exceeding five per cent. The influence of differences in school attendance was trivial compared with the influence of differences in intelligence. In spite of the great contemporary emphasis upon the pre-school social environment, there are those dissenters who maintain the hypothesis that within ordinary limits, and within a given social class and national group, the variable patterns of personality are in the main attributable to germinal differences. The environmental conditioning factors may provide the particular mode of expression for neuroses and eccentricities of character, but the general trend and the potentialities of adjustment are regarded as tracing back to birth episodes, to the circumstances of pregnancy, and dominantly, to the hereditary constitution.

After we have reviewed these conflicting claims, and the somewhat fragmentary evidence upon which they are based, it becomes very obvious that we are dealing here not with material for conclusions, but rather with problems for research—our field being an extension of that covered in the 1928 *Yearbook of the National Society for the Study of Education*. This very valuable contribution was concerned with nature and nurture: their influence upon intelligence, and their influence upon achievement. The present problem (which must later be greatly subdivided) is nature and nurture: their influence upon individual differences in emotional stability, and upon the organization of the personality.

At the Institute of Child Welfare of the University of California we are at present making two approaches to this problem. One is through the cumulative study of a large sample of

twins, with a comparison of developing differences in (A) identicals and in (B) fraternal twins of the same sex. Where the environmental conditions are comparable, we may assume that if the intrapair differences in B exceed those in A, this excess provides a measure of the effects of sibling variation in heredity.

Another advance into this general area of investigation, is marked by our study of a group of approximately 150 pre-school children, who are brought under closely supervised guidance procedures, and who are matched with paired controls. By comparisons of the experimental and the control groups, it should be possible to estimate the efficiency of the training methods employed.

Such studies cannot be expected to yield early results. Difficulties in the definition and measurement of traits, are much more perplexing than in the fields hitherto tilled by genetic research. There is no reason, however, to regard these difficulties as insurmountable.

Migration Statistics

INTERNATIONAL MIGRATIONS, Vol. I, Statistics, Introduction and Notes *by* IMRE FERENCZI; *Edited by* WALTER F. WILCOX. National Bureau of Economic Research. New York, 1929. 1112 pp., $10.

In this volume which contains about a thousand pages of tables are given the international migration statistics from the beginning of the record (in the 19th century) in each country through 1924. In a second volume these statistics are interpreted by scholars in different countries. This study, which grew out of the appointment by the Social Science Research Council of a committee to study migration, was financed by the National Bureau of Economic Research. The research was carried on under the direction of Dr. Imre Ferenczi of the International Labour Office. A careful introduction and voluminous notes by Dr. Ferenczi explain the sources of data, discrepancies, etc. As a source book for migration data, usually inaccessible, this volume is well worth its price which, in conformity with the National Bureau's policy, just covers the publication expenses.

Both national and international tables are given. In the former are found the statistics which record migrants at the time of departure and at their arrival in countries of residence. In the section dealing with international tables consideration is given to comparison of waves of migration, and to the basis on which uniform migration statistics can be built in the future.

Chief attention is given to the statistics of countries of immigration as this class of statistics is more complete than the statistics of emigration; the latter have been used chiefly to supplement and to check the former. The fairly close correspondence of the emigration with the immigration statistics, however, testifies to the pains taken to achieve accuracy in the face of inadequate records.

While neither the data nor the sources can be analyzed in a short review, it must be remembered that until 1815 there were no official migration statistics; that until 1850 the chief sources of data were the statistics of shipping companies, port statistics, statistics of countries through which migrants passed, and certain other statistics of immigrant countries. Not until after 1850 were records generally kept; not until 1900 were these records really satisfactory; and not until 1920 was an effort made to secure uniform and coordinated data. The chief value of the present work consists in

making these widely scattered data accessible. When possible data on age, sex, and occupation are given.

Dr. Ferenczi supplies a careful analysis of the factors motivating or retarding migration during different parts of the nineteenth century. Comprehension of these factors coupled with the growth of uniform statistics is essential to the initiation of scientific control of international migration. Only in the light of such statistical data can the economic consequence and causes of migration be thoroughly understood.

J. J. SPENGLER

Eugenics Explained

WHAT IS EUGENICS? *by* MAJOR LEONARD DARWIN. Pp. vii+88. Price $1.00. American Edition. Galton Publishing Co., New York. 1929.

Eugenics means many things to many people,—to most people just another "reform" in a world already rather over-reformed. The distinguished past president of the British Eugenics Education Society has performed a real service in giving a brief and readable account of what eugenics means to him. As President Angell of Yale observes in the introduction to the American edition, eugenics has fared rather badly from the efforts of some of its over-zealous friends (and, it might be added, infinitely worse at the hands of the headline writers of the tabloids—and even of the more conservative press—who delight to emphasize any spectacular marital innovation, and to add zest to other deviations neither innovations nor spectacular by labelling them "EUGENICS"). Persuasion and cooperation are the cornerstones of Major Darwin's eugenic edifice, and a wide distribution of the book should do much to correct the misconceptions engendered by the overzealous and the ignorant.

The contrast between British attitudes and American is in some instances rather striking, if Major Darwin's reactions are typical. In spite of a much franker linkage of eugenics with breeding than would ordinarily be undertaken by an American, Major Darwin seems rather unnecessarily squeamish about sterilization—"At present certainly the public would not tolerate any such proposal [compulsion of any kind] even if its justice could be fully proved" sounds conservative indeed to citizens of the "Land of the Free," whose Supreme Court has recently held (and rightly) that "the principle that sustains compulsory vaccination is broad enough to cover cutting the fallopian tubes." Justice is to be the keyword of eugenics, and yet it is seriously suggested that the husband of a woman subject to periodic insanity should submit to sterilization, because it is a more convenient operation in the male!

When we encountered the adjuration "consult your doctor" in problems hereditary and eugenic, we were encouraged to believe that the medical profession in England was rather more advanced in matters of heredity than their American confrères. A few sentences farther on this hope was dashed by the admission that "unfortunately at present very few doctors have given careful thought to such questions," so conditions in this respect seem very similar on the two sides of the Atlantic. Perhaps such a course would encourage the study of heredity among the medicality, but one wonders just how much value a patient should place on advice by a physician who has *not* "given careful thought."

Comments on differences of viewpoint have hardly given a fair indication of the value of the book. To make amends, and to emphasize the

excellent service that has been done the cause of eugenics in this addition to the "pocket literature" of the subject, we can do no better than to quote a few of the striking phrases and happy comparisons in which the book abounds:

Moreover, all reforms involve some risk. To do nothing is, however, often the course which involves most risk. The world is never really standing still; and to leave things alone may be merely to drift on to unseen rocks ahead. The bogey of dangers in the path of progress is often raised by us from an unconscious desire to save ourselves the trouble of making up our minds and of beginning to move in new directions. If science points clearly to certain steps which could now be taken in order to benefit our nation in the future, do not let us fail to move in that direction out of a selfish regard for our own comfort. Eugenics calls upon us to include all future generations amongst our neighbors; that is amongst those for whom we ought to be prepared to sacrifice our own immediate interests.

R. C. C.

The Dying Professor

A Study in Faculty Family Size

THE following is a distribution of the number of children of the forty-eight members of the staff of a good New England university. This institution is relatively small, as universities go today, having a student body of about 400, including about 50 in the graduate departments; it has a history of over forty years of academic distinction, and appears to be adequately endowed for the work it is attempting. For some two or three years its entering students have been markedly (about one standard deviation, in the middle ranges) superior to those of the country as a whole in scores on the Thurstone Intelligence Examination.

The distribution of children in the families of the faculty:

Children	0	1	2	3	4	5	6	Total
Frequency	21	8	7	7	2	2	1	48

This gives a total of 67 children, and a mean number of children per instructor of 1.40; the median would also be close to the same figure.

All individuals in the faculty directory have been included in the enumeration, from the president to the university physician and the librarian emeritus. There is therefore a complete age and rank range; and since the figures reported represent the *status quo*, it is possible that the completed families may be larger. Scrutiny on this point is of course highly unreliable, but may have some value when given in terms of limits. Three is the smallest number of individuals in the list for whom a wager would seem safe that they *might* add to the total number of offspring; the greatest number for whom there is any reasonable probability of such addition is about fifteen. These estimates are based upon such items as number of years of bachelorhood and personality type of bachelors, age of wife, age of youngest child and interval between children, known attitudes toward children and economics, and feminine confidences. If we take ten as a reasonable number of children yet to be produced, we have 77 as the total fertility, and a mean of 1.60. It is possible that a few deaths have not been reported, so that reduction to the "born alive" basis might give a figure as high as 1.65 or 1.70.

This should, if typical, give adequate insurance against any tendency for the office of college teacher to become hereditary. The professional eugenicists, with their figure of 2.08 children born alive, seem relatively quite fecund.

RAYMOND R. WILLOUGHBY
Clark University,
Worcester, Mass.

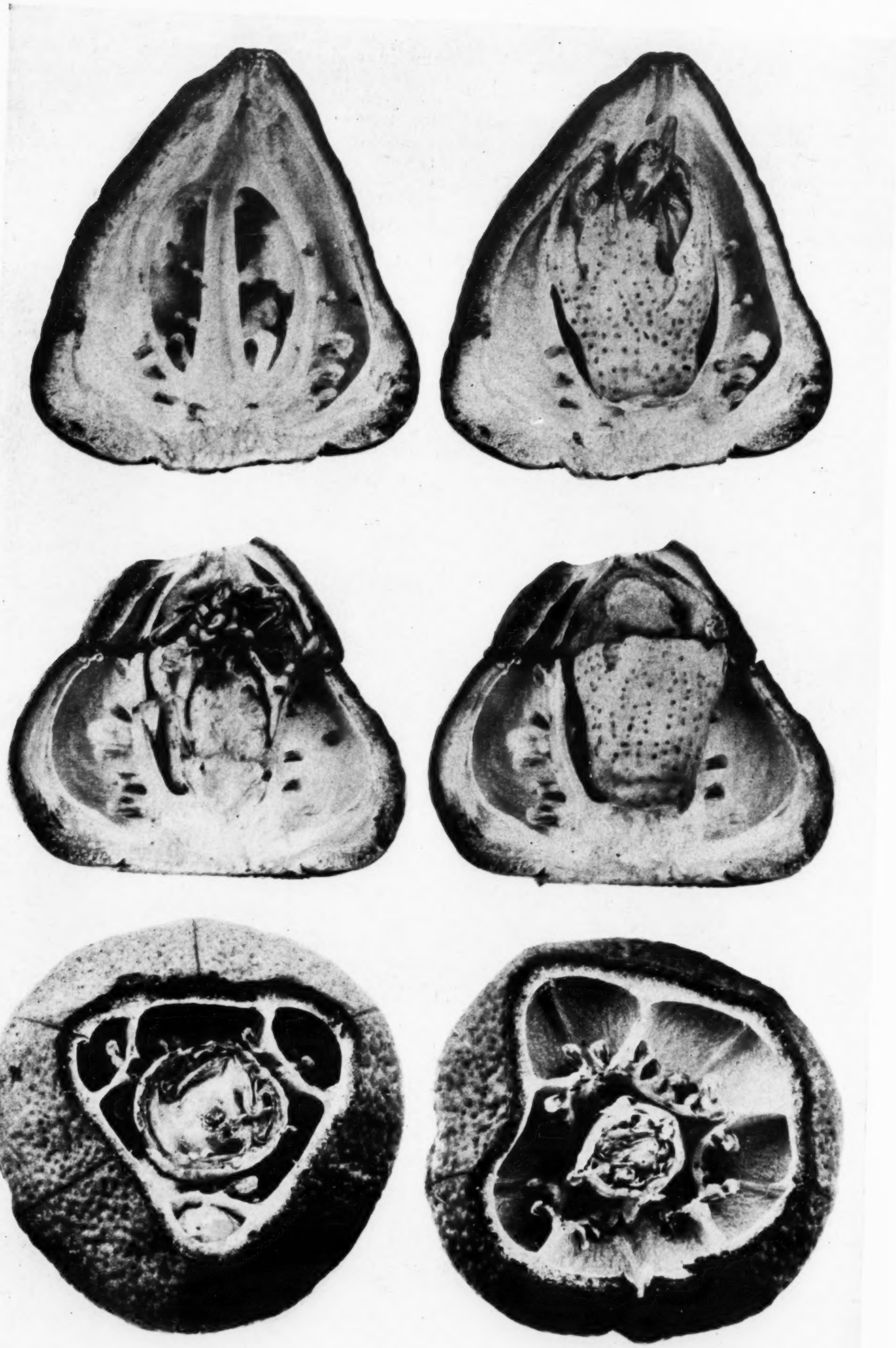


Figure 10

Explanation on opposite page

FLOWER BUDS IN COTTON BOLLS

J. W. HUBBARD
Senior Scientific Aid, Bureau of Plant Industry

MANY departures from normal development are found in the cotton plant, and some of the most peculiar aberrations have been found in fields of well established varieties. Wide variations occur frequently in mixed varieties, as a result of hybridization, and characters are often expressed that are unknown in the immediate parental stocks.

The wide range of variations shown in the Upland cotton plant is commonly attributed to the effects of earlier hybridization, and the degenerate forms are usually considered as reversions to some remote, ancestral type. These degenerates often exceed the normal range of character variations found in any of the cultivated varieties, but seldom go beyond a reasonable expectation of variation possibilities as indicated by the vast wealth of characters known in the wild and cultivated cottons of the world.

A cotton plant was found in a uniform field of Acala cotton at Shafter, California, in 1929 with distinct characters that have not been previously reported in the genus Gossypium. This plant in general appearance was only slightly different from the normal plants adjacent to it, but varied sufficiently that it was pulled out in roguing the field for an increase seed stock. The plant had made a rather large vegetative development, and had only a few immature bolls. It is unfortunate that the plant was pulled out before its real interest became known, as there were no seeds for reproduction.

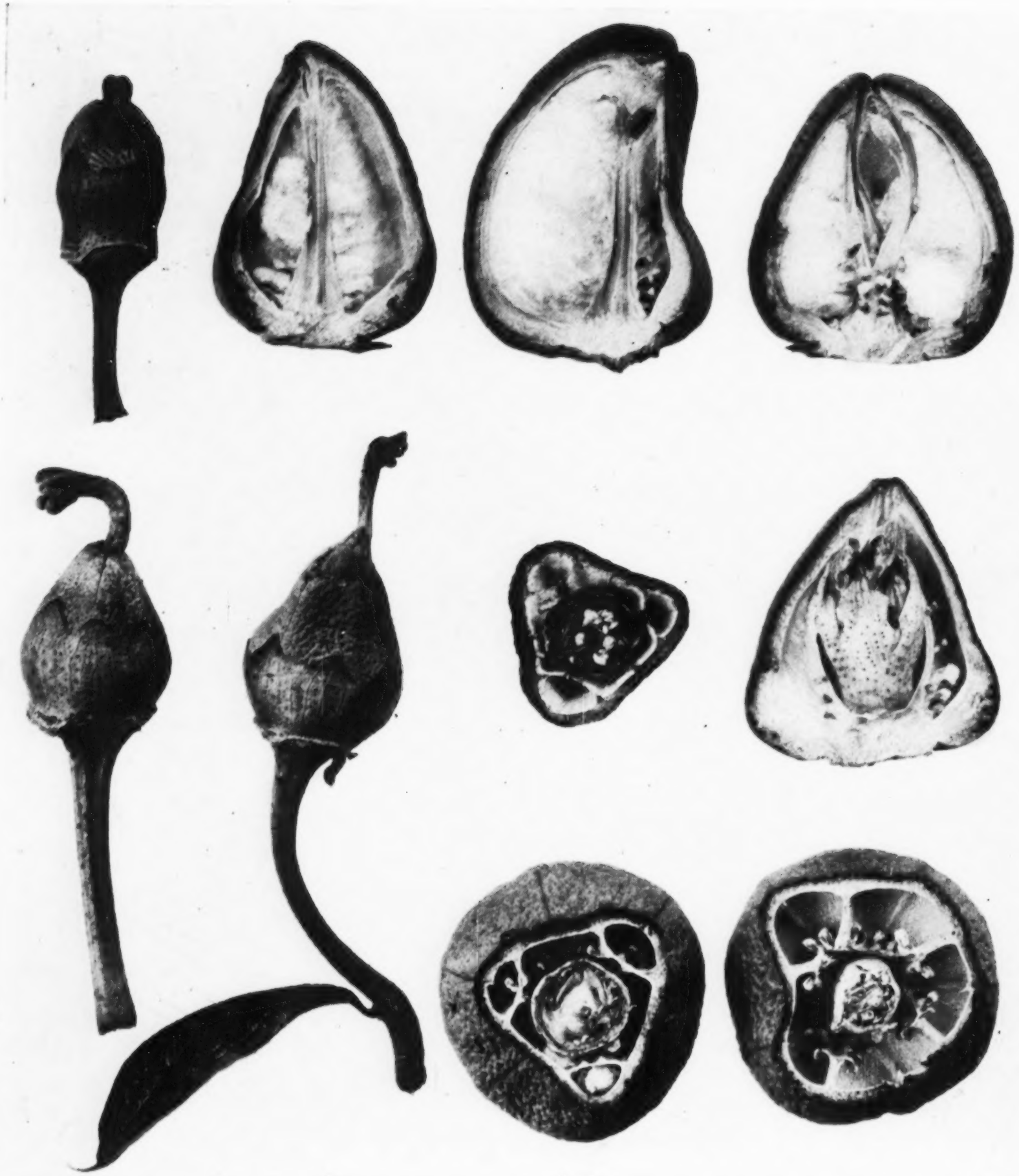
In pulling the plant from the row, the bolls were observed to be definitely off-type, being rather large and almost flat across the base, and tapering abruptly to a blunt point. One of these bolls was cut open to see if it contained supernumerary carpels, which had been found in large numbers in bolls of similar type during the roguing of seed fields in the San Joaquin Valley. The carpels of this boll were found to be empty, or to contain only very small, abortive seeds, and the placenta was expanded around a large fruiting bud that had almost attained the flowering stage. An examination of the remaining bolls on the plant revealed two more bolls containing flower buds, and other interesting variations.

The flower buds inclosed in these bolls were somewhat crumpled from having expanded against the tissues of the boll, but each of them was found to contain a complete set of floral organs with the exception of the involucral bracts. These organs varied from the normal development of Acala cotton in many respects, but were arranged in the regular manner. The calyx was large in comparison with the corolla and was deeply and irregularly cleft with long tailed lobes. The staminal column, stigma, and other organs inclosed in the corolla were somewhat deformed, but appeared capable of performing their functions in reproduction. The ovaries were poorly developed and contained only a few ovules, partially imbedded in the large placenta.

ENLARGED VIEWS OF BOLLS CONTAINING FLOWER BUDS

See Figure 10—On Opposite Page

Bottom, cross sections of two bolls with flower buds. Center, two longitudinal section views of the boll shown at lower left. Top, two longitudinal section views of a boll with flower bud at right, and with bud removed at left. (Magnified about two times).



ABNORMAL VARIATIONS OF BOLLS ON ROGUE COTTON PLANT

Lower right, three bolls with flower buds in center. Lower left, two bolls with large accrescent stigmas. Bolls in top row were badly misshapen, but with carpels containing immature seeds almost full size. Top left, flower bud showing stigma exerted before flower, all from one plant. (Natural size.) **Figure 11**

ENLARGED VIEW OF BOLLS WITH ACCRESCENT STIGMAS

The large accrescent stigmas appear to have no relation to the interior development of the bolls, but have remained persistent from flower. *The boll at right shows a large supernumerary carpel. About twice natural size.*

In addition to the bolls containing flower buds, two bolls were found with persistent, accrescent stigmas. Instead of falling off with the remainder of the flower, these stigmas had remained firmly attached and had continued to grow. At first sight of these stigmas it appeared as though a bud in a boll had flowered, but the stigmas were found to have no relation to the interior development, and these bolls did not contain flower buds. Other bolls were found to contain immature seeds that were almost full size and apparently of normal development.

About twice natural size.
large supernumerary carpel.

The Discoverer of Sex in Plants

(Illustration on Cover)

RUDOLPH JACOB CAMERER, or Camererius, deservedly is honored as one of the founders of the science of biology. His *De Sexo Plantarum Epistola,* a "letter" of fifty printed pages, addressed to Bernard Valentin of Giessen, and published in 1696, records the first *experiments* demonstrating sex in plants. It is true that the ancient Babylonians had pollinated the date palm artificially several thousand years before; that in Classical times Theophrastus had speculated with remarkable intuition on the phenomena of plant fertilization; that Grew, Millington, and Ray, in England, had some years earlier called attention to analogies between plants and animals in their means of reproduction, but Camerarius was the first to put his views to the test of experiment, the results being summarized in the *Epistola:* "They behave indeed to each other as male and female, and are otherwise not different from one another. They are thus distinguished with respect to sex, and this is not to be understood, as is ordinarily done, as a sort of comparison, analogy, or figure of speech, but is to be taken actually and literally as such."

From a eugenic point of view it is interesting that Camererius was a member of a family of distinguished botanists and physicians. His grandfather, Johann Rudolf Camererius, was "for his time a well-known doctor and the founder of a family known for the success of its members along scientific and medical lines." His father (Elias Rudolf, 1641-1695) was professor of medicine at the University of Tübingen. Rudolf Jacob himself received the degree of Doctor of Medicine in 1687; later he was appointed director of the Botanic Garden and Professor of Medicine at Tübingen. His son Alexander followed him as Professor of Medicine at Tübingen, so that for four generations this position on the Staff of that University remained in the family. Segregation of scientific ability may also be said to be demonstrated in the brother of Rudolf Jacob, Elias (1673-1734)—"a successful doctor, personal physician to the Duke of Würtemburg, but in reality a necromancer, believing in superstition and magic and opposed to new ideas and progress."

This family of Camerers does not appear to be related to the other distinguished family of that name which flourished nearly two centuries earlier, of whom the most famous was Joachim (1500-1574), of Tübingen, friend of Melanchthon, of whom it was said "All Europe ran a race to pay him homage as teacher, scholar and man." The name of this family was originally Liebhard, but the name Camerer was adopted when an earlier member of the family was appointed Chamberlin (Kammermister), a hereditary position in the family.

Effects of Sexual Sterilization

STERILIZATION FOR HUMAN BETTERMENT, *by* E. S. Gosney and Paul Popenoe. Pp. xviii and 202. Price $2.00. The Macmillan Company, New York. 1929.

The literature contains many lengthy accounts of damage, real or imaginary, done to society by the rapid multiplication of mental defectives and of the possible saving to humanity which would result from the prevention of such increase but this is one of the few authoratative reports which discusses at any length the practice of human sterilization. The data upon which the book is based consist of hospital reports on 6,255 sterilizations performed prior to Jan. 1, 1929, in California. Of this number 3,728 were men. Probably this is the largest number of cases which have been made available anywhere for study up to this time.

It appears that sterilization produces no change in the sexual life and the operation is both highly efficient and relatively free from danger to the individual. About one tenth of one per cent of failures of the operation are recorded, almost equally divided between men and women. Of course many of these operations were not voluntary and the main object was to prevent reproduction but it is interesting to note that in many cases there was a decided improvement in the patient's well being. This is due no doubt to the removal of the fear of pregnancy among those who are antagnostic to such a condition. The usual belief that sterilization will rapidly lead to sexual promiscuity is not borne out by the authors' findings. Very few cases of sexual delinquency were found among the sterilized men and women who were released from the state institutions and among those who were sterilized in private practice and for whom records were available. It is interesting to note that of the women who were voluntarily sterilized in private practice the reason given in the majority of cases was some physical impediment to childbirth. Eugenic reasons formed only a minor percentage of the total, as might be expected.

The book is divided broadly into two parts and an appendix. The first part of nine chapters discusses the facts and the second part of three chapters gives the conclusions relative to the personal, social and eugenic reasons for sterilization. The appendix gives among other things, a list of references, an address by Robert L. Dickinson on the surgical aspects of sterilization in California, a discussion of the law by Otis Castle, and some tabulations of data pertaining to sterilization.

H. C. M.

A Giant, Disease-Resistant Sugarcane

A giant type of sugarcane which grows 25 to 30 feet high in its native home, the island of New Guinea, is now making satisfactory growth at Canal Point, Fla., according to reports just received by the United States Department of Agriculture.

The cane in question belongs to a new species (*Saccharum robustum*) which has not yet been described botanically. It was located and brought back to the United States by Dr. E. W. Brandes, of the department, who made an exploration trip to New Guinea in 1928 in search of disease-resistant varieties.

Plants of the new species are vigorous growers and are resistant to many diseases which attack sugarcane in this country. The sugar content of the new cane is rather low, and for this reason plans are being made to cross it with other plants having higher sugar content. This work will take several years.

In April about 80 varieties of sugarcane cuttings were sent to the Canal Point field station for trial planting. Before these cuttings could be planted in Florida they had to grow in quarantine at the Arlington Experimental Farm for one year to prevent introduction of new pests or diseases.

U. S. Dept. of Agri.

ON THE INHERITANCE OF AN ANOMALY OF HUMAN DENTITION

C. Leonard Huskins
John Innes Horticultural Institution, Merton, London

RECORDED studies of anomalies of human dentition reveal a wide range of diversity both in themselves and in the opinions held concerning them. Downs,[3] for example, quotes ten authors who incline towards the view that the anomalies they have observed are due to some endocrinal dyscrasia, and eight who favour genetic explanations. The conclusions from his own observations and experimental work are summarized as follows:

> Although it is possible that dental anomalies may sometimes appear as the result of endocrinal dyscrasias, just as may be the case with vitamin deficiencies or other developmental interference. . . . . Dental anomalies probably cannot be considered as pathognomonic of any definite type of endocrine dyscrasia.

Dental anomalies which are clearly inherited vary in type, in degree of expression, and in mode of inheritance. Three fairly recent papers illustrate the diversity. Thadani[6] reports sex-linked inheritance of the entire absence of teeth and of hair in a race living in India. Ovazza[5] describes a family in which the absence of all incisor teeth is inherited as a simple mendelian dominant. Beadle[1] describes an anomaly of dentition which is also inherited as a single factor dominant, but the expression of the anomaly varies greatly. Varying numbers of teeth are sporadically absent from either the deciduous or the permanent set, and there are also irregularities in the age of eruption of the teeth.

The case to be described here has resemblances to both Thadani's and Beadle's cases. In its extreme expression the anomaly is the absence from both sets of teeth of the two center incisors of both upper and lower jaw. The pedigree starts with a family of four males and one female. The oldest male, born 1781, and the youngest, born 1795, had the anomaly in its extreme form. It is stated that the defect occurred in their mother's family, but no details are available. The information has been obtained independently from numbers III-3 and III-19 of the pedigree in terms of personal relationships to themselves and from entries in the flyleaves of a Family Bible and a Prayer Book in the possession of III-19. When assembled as a pedigree chart the data from these three sources were found to be in agreement. This together with the fact that the anomaly is a striking one and that my informants, though very interested in the occurrence of the defect, had no knowledge of laws of heredity, seems to ensure the reliability of the data.

It has not yet been possible to trace the inheritance of the anomaly in descendants of any of the other four members of generation I of this pedigree. Most of the family lived in the Midlands of England until comparatively recently, but they are now somewhat scattered. The names and addresses of many of the members of the pedigree have been filed in the records of this institution and will be available for confidential use by persons studying anomalies in families which may possibly be thought to be related.

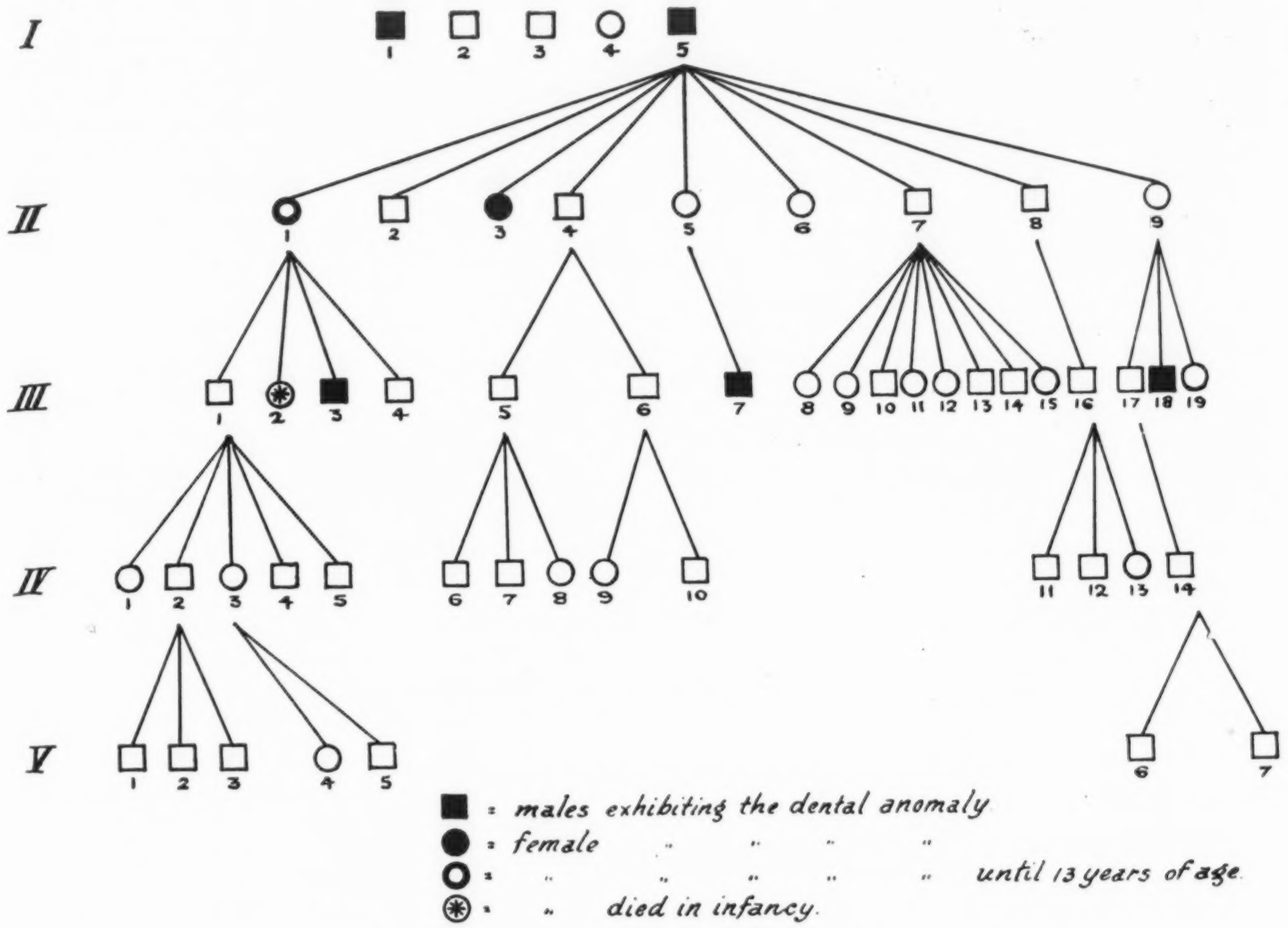
Male I-5 married an unrelated normal woman and had five female and four male children. Of these the eldest, a female, lacked the teeth in question until the age of thirteen. Her son says she often told her family that the "cutting" of the missing teeth at this age was extremely painful. She married a second cousin, the son of a daughter

of her paternal grandfather's brother. As the defect came into the family through the mother, this consanguineous marriage has no bearing on the inheritance of the anomaly in question. Male II-2 had normal dentition. He died unmarried. Female II-3 had the defect in its extreme form. She died shortly after marriage at a comparatively early age. Female II-6 had normal dentition. She died young and unmarried. The remaining members of generation II had normal dentition, married normal individuals as far as is known, and had offspring as shown in the pedigree chart.

Male III-1 had normal dentition. He married a normal unrelated woman and had five children and five grandchildren, all normal. Female III-2 died at the age of ten weeks and therefore cannot be considered in this pedigree. Male III-3, one of my informants, never developed the two center incisors in either jaw. Late in life he married a woman of mature age. They have no offspring. No. III-4 had normal dentition. He was subject to epileptic fits and died of smallpox in 1883, three weeks after marriage. No. III-5 had normal dentition and his three children were normal in this respect, though the eldest son exhibited syndactyly. As different abnormalities of the hands can be correlated in inheritance it seems probable that this defect came into the pedigree through the mother, as her brother was polydactylous. Male III-6 had normal teeth and normal offspring. No. III-7 never developed the central incisors in either jaw. He married but had no children. Individuals III-8 to III-15, the progeny of II-7, all had normal teeth. Five of the females and one of the males are married. Not all of their offspring are known to my informants, but they know 23 of them, and all of these are normal. It seems scarcely worth while, therefore, to attempt to trace this branch of the family in detail, and this incompletely known generation is not included in the pedigree chart. Male III-16 had normal dentition and has three normal offspring. Male III-17 is normal and has a normal son and two normal grandsons. Male III-18 had normal dentition of the upper jaw but lacked the center incisors of the lower jaw. Apart from this deficiency his teeth were especially good, and up to the time of his death in middle life he never had dental treatment. He was unmarried. Female III-19 has normal teeth of fair quality. After tooth extraction she suffers from abnormally severe bleeding, but can scarcely be regarded as haemophilic. She is unmarried. The individuals comprising the remaining two generations of the pedigree chart all have normal dentition, and need not be considered in detail.

The inheritance of this dental anomaly seems clearly to be sex-linked. Its *transmission* agrees exactly with the expected distribution of an abnormality factor carried by one of the *X* chromosomes of the mother of generation I. The only irregular feature is in the expression of the factor. Five females of the pedigree (II-1, 3, 5, 6 and 9) should be heterozygous for the defect and two (I-4 and III-19) should have equal chances of being either heterozygous or normal. Of the five, the three who had progeny *were* all heterozygous. In three of the five including two proved heterozygotes, the defective character behaved as a complete recessive, while in one (II-3) it was a complete dominant, and in II-1 it was dominant up to the age of thirteen and then recessive. If either or both of the two 'possible heterozygous' females carried the defective factor, it was recessive in them. Exactly half of the sons of heterozygous females show the defect, but one (III-18) lacked the teeth in question in the lower jaw only and had normal dentition in the upper jaw, though presumably having only one *X* chromosome, he should have carried only the abnormality factor, and not its normal allelomorph.

Clearly the inheritance of this dental anomaly is subject to the influence of either modifying factors or environ-



A SEX-LINKED DENTAL DEFECT

Figure 12

In its extreme expression the individuals exhibiting the anomaly lack the two center incisors in both upper and lower jaw. All matings are with normals, and except in the case of the two females, II-1 and 3, the character behaves as a recessive, being transmitted from an affected male to half his daughters' sons.

mental conditions. If it is a fact that endocrine secretions can affect the development of the teeth, the eruption of teeth by II-1 near the age of the onset of puberty might possibly indicate a correlation with sexual secretions.

There is no evidence of any other defective condition being associated with this dental anomaly. This is in marked contrast to the case recorded by Thadani, in which there is entire absence of hair and teeth, and to the cases in cattle and rabbits recorded by Cole[2] and Kislovsky[4] in which abnormal hair development and lack of hair accompany dental defects.

In generation III of this family, it seems just possible that sexual selection played a part in the elimination of the defect. Of the 15 normal members of this generation who reached maturity only one remained unmarried. Of the three defective members one never married, and another married only in his old age.

Author's Note: Since the above was written I have succeeded in tracing 51 descendants of I-1. This individual had six sons and two daughters. None of the sons would be expected to transmit the defect, and the fact that the 44 of their descendants who have been traced are all normal is therefore satisfactory negative evidence.

The two daughters of I-1 should have been heterozygous for the defect and should have transmitted it to half of their offspring. One of them died unmarried; the other had two daughters. These would have an even chance of receiving the defective factor. I have not yet been able to trace the descendants of one of them. The other had two daughters

and one son, all normal. If she did carry the defect these three children should again have had an equal chance of receiving it. Only one of these three, a daughter, is married and she has one son and one daughter, both normal. The mathematical chances of the defect being carried through the female line in these generations III, IV and V from I-1, being halved each time, are of course ½, ¼ and ⅛, respectively. The absence of any appearance of the defect in this line is therefore quite inconclusive, and neither for nor against the hypothesis that it is due to the action of a factor borne on an *X*-chromosome.

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Early Chinese Record of a Mutation in Rice

In a communication to *Nature* (London), dated May 3, 1930, Hugh Nicol of the Rothamsted Experiment Station calls attention to an extremely interesting and detailed account of the discovery and utilization of a mutant rice-plant, showing unusual earliness and other desirable agronomic qualities, by the emperor Khang-hi (who reigned from 1662 to 1723). The account is to be found on page 470 of the 1859 edition of an English translation of "The Chinese Empire" by Monsieur Huc:

"'I was walking,' says the Emperor Khang-Hi, 'on the first day of the sixth moon, in some fields where rice was sown, which was not expected to yield its harvest until the ninth. I happened to notice a rice plant that had already come into ear; it rose above all the rest, and was already ripe. I had it gathered and brought to me; the grain was very fine and full, and I was induced to keep it for an experiment, and see whether it would on the following year retain this precocity, and in fact it did. All the plants that proceeded from it came into ear before the ordinary time, and yielded their harvest in the sixth moon. Every year has multiplied the produce of the preceding, and now for thirty years it has been the rice served on my table. The grain is long, and of a rather reddish colour, but of a sweet perfume, and very pleasant flavour. It has been named *ya-mi*, or 'Imperial rice,' because it was in my gardens that it was first cultivated. It is the only kind that can ripen north of the Great Wall, where the cold begins very early, and ends very late, but in the provinces of the south, where the climate is milder, and the soil more fertile, it is easy to obtain two harvests a year from it . . .'"

M. Huc adds that this rice was introduced into Manchuria, and that it succeeds admirably in dry countries, having no need for perpetual irrigation. He thought it would certainly prosper in France, but although he sent several samples to that country he never heard that any experiment was tried with it.

Two French books allude somewhat vaguely to this rice. "Le Rapport sur les Céréales: Exposition Universelle" (Paris, 1878), mentions the above story and offers the alternative name *riz précoce*. "Les Plantes de grand culture" (Paris, 1893), says that there appears to be a variety of rice in China which completes its growth in less than three months.

The variety is probably identical with the *yu-mi* (*Oryza communis Pyrocarpa* Al.) which is the only variety specifically attributed to China by M. A. Carleton (The Small Grains; New York, 1916).

Nature 125: 818.

GENETIC STUDIES IN BARLEY

D. W. Robertson and G. W. Deming
Agronomy Section, Colorado Agricultural Experiment Station

THE occurrence of chlorophyll deficient seedlings has been previously reported in barley and several studies have been made to determine their mode of inheritance and linkage relations. Nilsson-Ehle[4] describes six chlorophyll mutations, three albinos, two yellow and one chlorina. All of the albinos are recessive to green and a linkage was found between albino 3 and chlorina. All of the other chlorophyll deficiences were found to be independently inherited. Hallquist[2] made crosses between the following chlorophyll deficiencies: Albino 1, Albino 2, Albino 4, Xantha 1, Xantha 2, Chlorina, Superchlorina, Virescent 1, Virescent 3 and Lutescens. Forty-two out of 78 possible combinations were made. In crosses involving different albinos a ratio of green to albino of 9 to 7 was obtained and in a cross between virescent and a xantha; green, xantha and virescent seedlings occurred in a ratio of 9:3:4. The linkage of Albino 3 and Chlorina, found by Nilsson-Ehle, was confirmed and a linkage of Albino 4 with Albino 3 and Chlorina was found.

Two cases of temperature effect on development of chlorophyll have been reported, one by Hallquist[3] and one by Collins[1]. Chlorophyll development was stimulated in chlorophyll deficient seedlings by an increase in temperature.

Robertson[6] studied the interrelationship of three chlorophyll deficient seedling characters with other botanical characters. Two of the chlorophyll deficient seedlings, albino, (A_C a_C) and xantha, (X_C x_C) found in Colsess were closely linked. An indication of loose linkage was also found between albino, (A_C a_C) and hoods versus awns, (Kk). Albino (A_T a_T), found in Trebi, was linked with black versus white glume color.

Several other chlorophyll deficient seedlings have been found and their possible linkage relationship studied. A chlorina seedling was found in Colsess (Figure 14) which grew to maturity. The mature plants, however, are less vigorous than the normal green plants and are lighter in color. According to Ridgeway[5] plate XVII they are Dull Green-Yellow. These chlorina seedlings are recessive to normal green. Three chlorophyll deficient seedlings were found in Coast barley,—a yellow seedling (Ridgeway plate IV Empire yellow), a white seedling and a virescent seedling. The virescent seedling (Figure 13) dies in the seedling stage. The seedling comes up white with a very marked green tip, which remains green. The amount of green on the second leaf is very small or lacking entirely. The seedling seldom survives farther than this stage. All of the chlorophyll deficient characters are recessive to normal green and segregate in a ratio of three green to one chlorophyll deficient indicating a single factor difference. The following letters will be used to indicate the different chlorophyll deficient types. Green versus chlorina in Colsess, (F_C f_C), green versus yellow in Coast barley (X_{C2} x_{C2}), green versus white in Coast (A_{C2} a_{C2}) and green versus virescent in Coast (Y_C y_C).

In studying the inheritance of various chlorophyll deficiencies, plants which were heterozygous for the character were used as parents. This was necessary because plants which were homozygous recessive for white, yellow or virescent seedling factors did not grow to maturity. Plants homozygous for the chlorina factor grew to maturity and in this case plants were used in the crosses which were homozygous for the recessive condition. When one

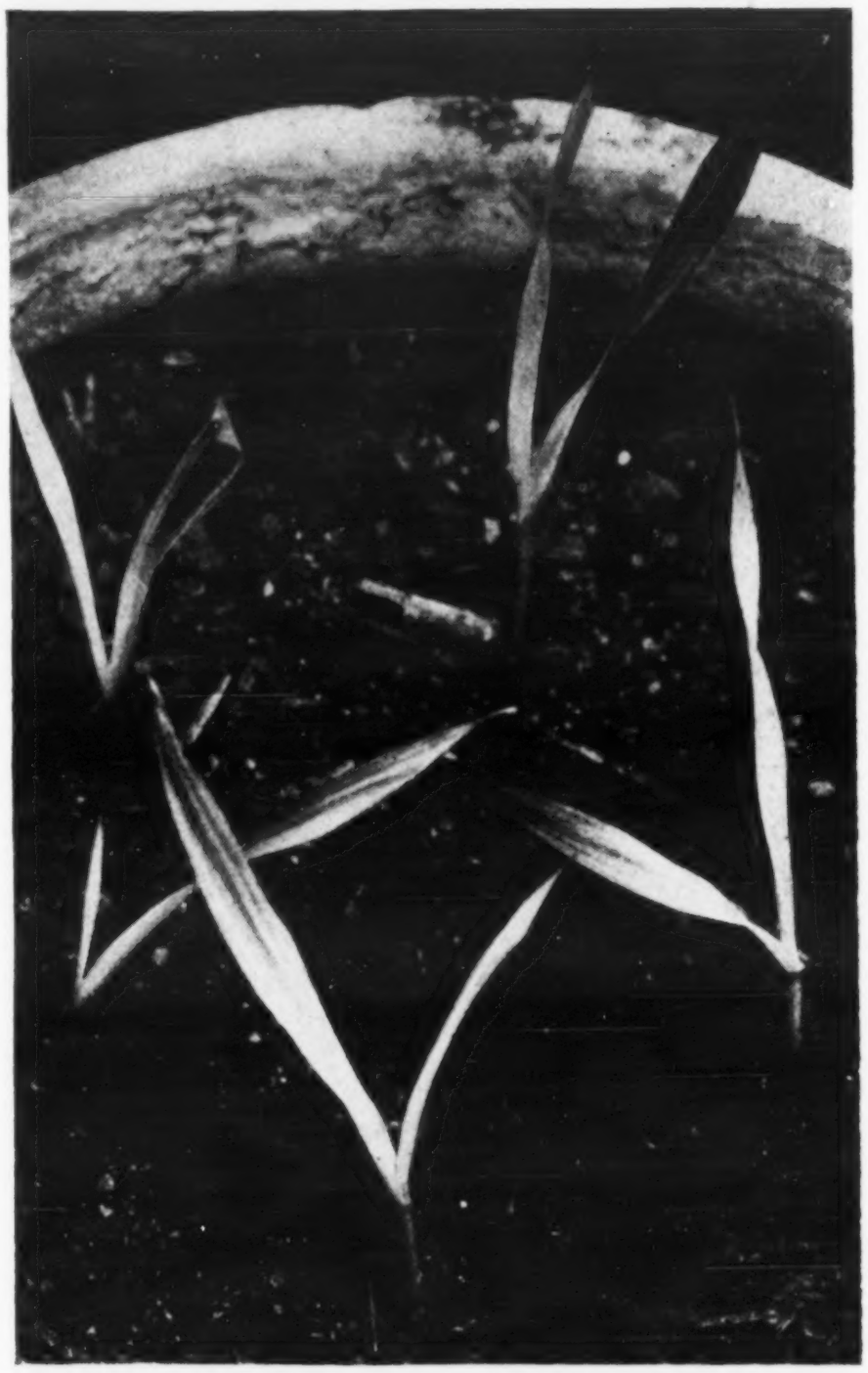
parent was heterozygous for green and white seedlings, and the other parent was homozygous for green, two types of F_1 plants were obtained; one being homozygous for the green seedling factors and the other heterozygous for the green and white seedling factors. Similar conditions are found with the yellow and virescent seedlings studied. In crosses in which both parents were heterozygous for different chlorophyll deficiencies, four types of F_1 plants were obtained.

By growing seedling progeny of F_1 plants in the greenhouse, it was possible to determine fairly accurately the genetic nature of the parent for chlorophyll deficiencies. Particular genetic types were used to make more extensive studies in the later generations.

Interrelations of Chlorophyll Deficiencies

Plants homozygous for chlorina seedling color were crossed with plants heterozygous for white seedlings (A_C a_C), found in Colsess. Twenty-nine F_1 plants were obtained all of which were pure green indicating that the factor pairs (A_C a_C) and (F_C f_C) are not allelomorphic. Two types of F_1 plants were obtained, one segregating in the F_2 for green and chlorina and the other segregating for green, chlorina and white seedlings. The progeny of 29 F_1 plants were tested in F_2. Sixteen produced green and chlorina seedlings and thirteen produced green, chlorina and white seedlings.

The interrelationships of the character pairs (A_C a_C) and (F_C f_C). were studied in the plants segregating for green, chlorina and white seedlings. On the basis of independent inheritance a 9:3:4 ratio is expected. Three thousand seven hundred and thirteen seedlings were counted in the F_2 and 2119 were green, 677 chlorina and 917 white. Calculation of X^2 for goodness of fit gave a P. value of 0.5810. In order to further test the possibility of linkage, progeny of the green and chlorina plants from the F_2 families

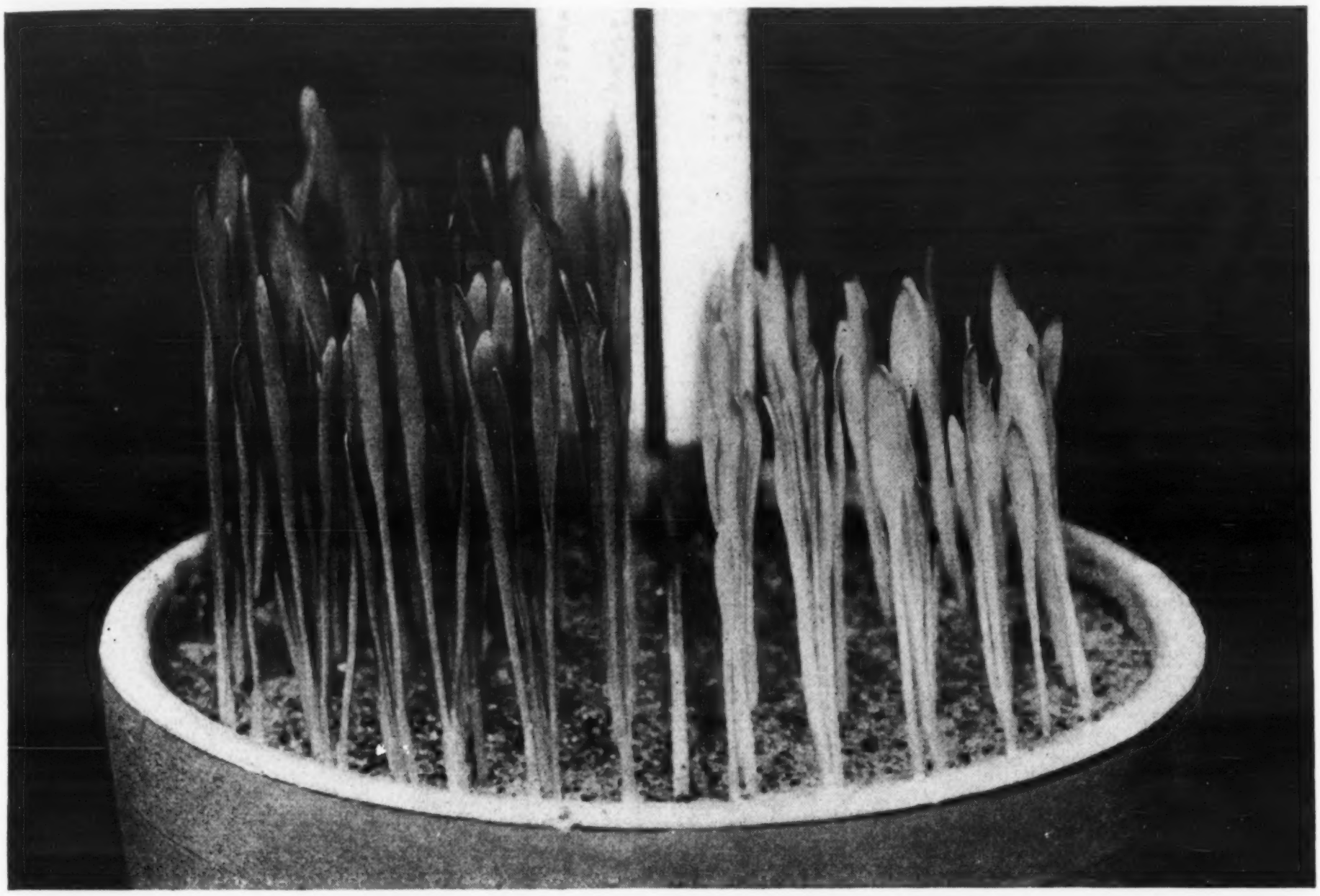


VIRESCENT SEEDLINGS

Figure 13

Virescent seedlings found in Coast barley. Tip of the first leaf has a very marked green tip which remains green, but the second leaf has very little chlorophyll, and the seedlings rarely survive beyond this stage.

segregating into green, chlorina, and white seedlings were grown in the F_3 and seedling counts made. With independent inheritance one F_2 green plant on the average out of nine should produce only green seedlings in the F_3, two should segregate for green and chlorina seedlings, two should segregate for green and white seedlings, and four should give green, chlorina and white seedlings. The X^2 test was used to determine the goodness of fit of the observed to the calculated ratio for independent inheritance. Of the 933 green plants tested 114 bred true for green, 197 segregated for green and chlorina, 212 segregated for green and white and 410 segregated for green, chlorina and



GREEN AND CHLORINA SEEDLINGS

Figure 14

These chlorina seedlings found in Colsess barley are greenish-yellow. Sufficient chlorophyll is present so that they grow to maturity. The character is a simple recessive to normal green.

white. The P. value obtained for this ratio when tested with a 1:2:2:4 calculated ratio was 0.6405. The data examined indicate that the factor pair (A_C a_C) is inherited independently of the factor pair (F_C f_C). Similar data were obtained when chlorina plants were crossed with plants heterozygous for green and xantha seedlings (X_C x_C).

A similar cross was made with chlorina plants and plants heterozygous for the white seedling factor pair (A_T a_T), found in Trebi. The same method of study was used in this cross as in the previous crosses. The X^2 calculations indicate that the factor pair (A_T a_T) is inherited independently of the factor pair (F_C f_C). Of the 3258 seedlings counted in F_2, 1837 were green, 616 were chlorina and 805 were white. The X^2 value was less than 1, giving a P. value which was very large. Progeny of 547 F_2 green plants were tested in F_3, 67 of these bred true for green, 121 segregated for green and chlorina seedlings, 114 segregated for green and white seedlings and 245 segregated for green, chlorina and white seedlings. The observed F_3 segregation of the progeny of F_2 green plants agreed very well with the calculated ratio. A calculated value of P. = 0.7722, further indicated independent inheritance of the factor pairs (A_T a_T) and (F_C f_C). These results would indicate that the factor pair (F_C f_C) for green versus chlorina seedlings is in a different linkage group than the factor pairs (A_C a_C) and (X_C x_C) which were previously found to be linked. The factor pair (A_T a_T) also seems to be inherited independently of the factor pair (F_C f_C).

Further studies were made to determine the possible linkage of the factor

pairs (F_C f_C) for green versus chlorina seedlings and the factor pair (X_{C2} x_{C2}) for green versus yellow seedlings and (A_{C2} a_{C2}) for green versus white seedlings. In the cross involving the characters chlorina and yellow seedling color the F_2 segregation was 615 green 209 chlorina and 264 yellow seedlings. When the X^2 test for goodness of fit was applied a value for X^2 of 0.3725 was obtained and P. in this case was very large.

The cross involving the factor pairs (F_C f_C) and (A_{C2} a_{C2}) gave an F_2 segregation of 1843 green, 673 chlorina and 867 white. When the X^2 test for goodness of fit to a calculated 9:3:4 ratio was used a P. value of 0.0939 was obtained. The progeny of F_2 green plants were grown in F_3 and breeding behaviour observed. The number of green F_2 plants in the different F_2 genotypic classes as determined from F_3 breeding behaviour are as follows, 71 were homozygous green, 129 were heterozygous for green and chlorina, 129 heterozygous for green and yellow and 279 heterozygous for green, chlorina and yellow. Compared to a 1:2:2:4 ratio these results gave a calculated P. value of 0.7994.

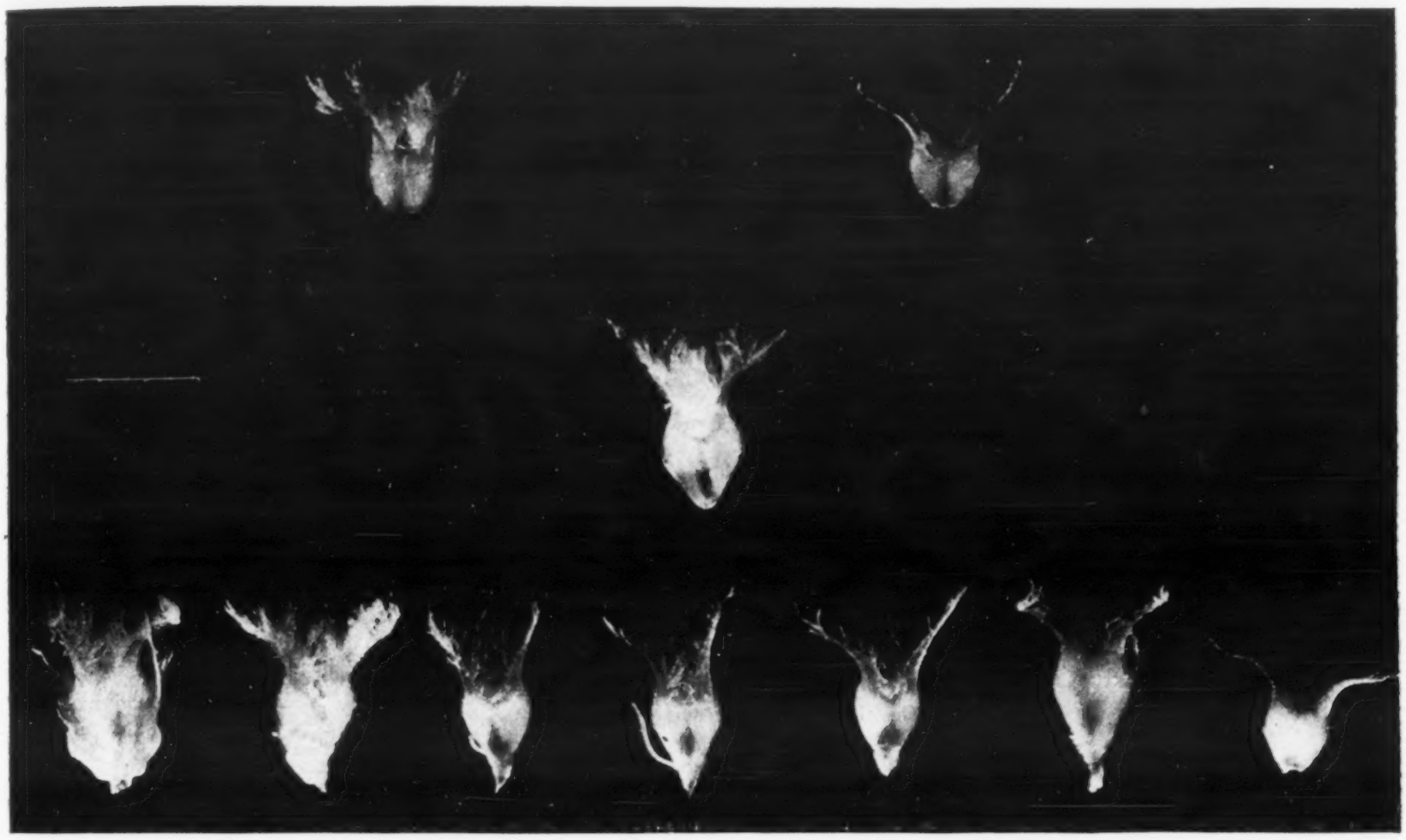
Crosses were made between Colsess plants heterozygous for the white seedling factor pair (A_C a_C) and Coast plants heterozygous for the following factor pairs: (X_{C2} x_{C2}), for green versus yellow (Y_C y_C) for green versus virescent seedlings. The yellow seedling factor pair (X_{C2} x_{C2}), was found to be inherited independently of the factor pair (A_C a_C), for green versus white seedling in Colsess. The observed F_2 ratio was 806 green, 291 yellow and 398 white seedlings. When X^2 was used to determine the goodness of fit of the observed to a calculated 9:3:4 ratio, a P. value of 0.1859 was obtained. A high P. value was also obtained when the yellow seedling factor pair (X_{C2} x_{C2}), in Coast was tested with the Xantha seedling factor pair (X_C x_C), in Colsess. Further tests in F_3 indicate that the factor pair (X_{C2} x_{C2}), for yellow seedlings in Coast is inherited independently of factor pairs, (A_C a_C), and (X_C x_C) which are linked.

Virescent seedlings in Coast were found to be inherited independently of the factor pairs (A_C a_C) and (X_C x_C).

The white seedling factor pair (A_{C2} a_{C2}) in Coast was found to be different from the white seedling factor pair (A_C a_C) in Colsess. From tests in the F_3 the indications are that these two factor pairs for green versus white seedlings are inherited independently of each other.

Crosses were made between hooded and awned plants heterozygous for different chlorophyll deficient seedlings. The factor pairs (X_{C2} x_{C2}) (Y_C y_C) and (F_C f_C) were studied. In the cross involving the factor pairs (Kk) for hoods versus awns and (X_{C2} x_{C2}) for green versus yellow seedlings a F_2 segregation was obtained of 346 hooded green plants, 106 awned green plants and 167 yellow seedlings which contained both hooded and awned factors.

When the X^2 test for goodness of fit to a calculated 9:3:4 ratio was used a P. value of 0.4067 was obtained indicating that the factor pair (Kk) is inherited independently of the factor pair (X_{C2} x_{C2}). In the cross involving the factor pair (Kk) for hoods versus awns and ($Y_C y_C$) for green versus virescent seedlings a P. value of .4456 was obtained. The observed F_2 frequency was 1037 hooded green plants, 340 awned green plants and 428 virescent seedlings. The virescent seedling class contains both the hooded and awned factors although they could not be grown to maturity and definite counts of each class made. In the cross in which the interrelationship of hoods versus awns and green versus chlorina were studied the number of awned plants was less than the calculated three to one ratio. The actual number of plants segregating in F_2 was 2400 hooded green, 852 hooded chlorina, 766 awned green and 233 awned chlorina. The X^2 test for independ-



INHERITANCE OF STYLE BRANCHING

Figure 15

Above at the left is shown the branched style found in Coast barley; at the right the smooth style characteristic of Lyon barley. The F_1 plants have a fully branched style (center), and in the next generation a graded series is found, running all the way from the smooth style to the fully branched. The numbers obtained indicated that the facts observed could be accounted for by the existence of three pairs of cumulative factors which determine the degree of branching of the style.

ence gave a P. value of 0.0683 indicating independent inheritance of the factor pairs (Kk) and F_C f_C). These data further agree with the previous findings which indicate that the three chlorophyll deficient factor pairs studied are inherited independently of the factor pairs (A_C a_C) and (X_C x_C). The latter two factor pairs show a possible loose linkage with the factor pair (Kk) for hoods versus awns.

Branched Versus Smooth Style

In crosses between Coast and Lion there is difficulty in obtaining a large percentage of seed when Lion is used as the female parent. When Coast is used as the female parent high percentage of fertilized seed are easily obtained. The style of Lion is not profusely branched. It has a single point on each branch. (See Figure 15.) The style of Coast is finely branched and almost feathery in appearance. In crosses between Coast and Lion the F_1 has a finely branched style indicating the dominance of branching over smooth style. Counts were made of the F_2 segregation in 1928 and 1929. All gradations of style branching were obtained between the profusely branched Coast and the smooth style of Lion. (Figure 15.)

The classification of the material into definite groups was very difficult. Two classes were finally decided upon, branched and smooth. The branched style includes all the plants showing any branching and the smooth style class includes only plants with unbranched style like the Lion parent.

The observed ratio of branched and smooth styles was compared with a calculated 63 to 1 ratio of branched to smooth. The X^2 test of six families totaling in all 2529 plants gave a P. value of 0.5384 which indicates a good

fit of observed to the calculated ratio of 63:1. These results can be explained by three factor pairs.

Assuming a three factor difference the genetic constitutions of Coast and Lion are represented as follows: $G\,G$, $G'\,G'$, $G''\,G''$ represents the branched condition found in Coast and $g\,g$, $g'\,g'$, $g''\,g''$, represents the smooth condition found in Lion. On this hypothesis these factor pairs are inherited independently of each other and there is a cumulative effect dependent upon the number of dominant genes present.

Summary

The following chlorophyll deficient seedling types were described, Chlorina, (F_C f_C) in Colsess barley, yellow (X_{C2} x_{C2}) in Coast barley, white (A_{C2} a_{C2}) in Coast barley and Virescent (Y_C y_C) in Coast barley. All of the above characters were found to be recessive to normal green and each was dependent upon a single factor difference.

The factor pairs (A_C a_C) and (X_C x_C) for green versus white and green versus xantha seedlings previously studied were inherited independently of the following factor pairs: (F_C f_C) for green versus chlorina seedlings, (X_{C2} x_{C2}) for green versus yellow seedlings (A_{C2} a_{C2}) for green versus white seedlings and (Y_C y_C) for green versus virescent seedlings.

The factor pair (A_T a_T) for green versus white seedlings in Trebi is inherited independently of the factor paid (F_C f_C) for chlorina seedlings.

The factor pair (F_C f_C) for green versus chlorina seedlings in Colsess is inherited independently of the factor pair (X_{C2} x_{C2}) for green versus yellow seedlings and the factor pairs (A_{C2} a_{C2}) for green versus white seedlings.

The factor pair (Kk) for hoods versus awns is inherited independently of the factor pair (X_{C2} x_{C2}) for green versus yellow seedlings (Y_C y_C) for green versus virescent seedlings and (F_C f_C) for green versus Chlorina seedlings.

A three factor difference was found between the smooth style of Lion and the feathered style of Coast. The factor pairs are designated as $G.\,g.$, $G'\,g'$, $G''\,g''$.

It is proposed to study the linkage relations of the three chlorophyll deficient types with the following linkage groups now known:

1. Green versus white seedlings (A_C a_C), green versus xantha seedlings and possibly hoods versus awns.

2. Black versus white glume color (Bb) and green versus white seedlings (A_T a_T). The following independently inherited factors pairs will also be studied: Vv for non six-row versus six row. Nn for covered versus naked and Ss for long versus short haired rachilla.

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